WATER RESOURCES DEVELOPMENT PROJECT

SAXONVILLE LOCAL PROTECTION

Framingham

SUDBURY RIVER

MERRIMACK RIVER BASIN

FRAMINGHAM, MASSACHUSETTS

DESIGN MEMORANDUM NO. 4

EMBANKMENTS & FOUNDATIONS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

JANUARY 1975

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

IN REPLY REFER TO

NEDED-E

23 January 1975

SUBJECT: Saxonville Local Protection Project, Sudbury River, Merrimack River Basin, Framingham, Massachusetts, Design Memorandum No. 4 - Embankments and Foundations

HQDA (DAEN-CWE-B)
WASH DC 20314

In accordance with ER 1110-2-1150, there is submitted for review and approval, DM No. 4, Embankments and Foundations, for the Saxonville Local Protection Project.

FOR THE DIVISION ENGINEER:

George T Sarandes
for JOHN Wm. LESLIE
Chief, Engineering Division

Incl (10 cys)
as

WATER RESOURCES DEVELOPMENT PROJECT

SAXONVILLE LOCAL PROTECTION

SUDBURY RIVER, MERRIMACK RIVER BASIN

FRAMINGHAM, MASSACHUSETTS

DESIGN MEMORANDA INDEX

No.	Title	Anticipated Submission Date	Date Submitted	Date Approved
1	Hydrologic Analysis		12 Dec 72	23 Feb 73
2	General Design - Phase I - Plan Formulation		30 Apr 73	27 Aug 73
2	General Design - Phase II		26 Jul 74	5 Sep 74
3	Concrete Materials	Mar 75		
4	Embankments and Foundations		23 Jan 75	
5	Design of Structures		19 Sep 74	30 Oct 74

WATER RESOURCES DEVELOPMENT PROJECT

SAXONVILLE LOCAL PROTECTION
SUDBURY RIVER
MERRIMACK RIVER BASIN
FRAMINGHAM, MASSACHUSETTS

DESIGN MEMORANDUM NO. 4
EMBANKMENTS AND FOUNDATIONS

CONTENTS

LIST OF PLATES

APPENDICES

WATER RESOURCES DEVELOPMENT PROJECT

SAXONVILLE LOCAL PROTECTION
SUDBURY RIVER
MERRIMACK RIVER BASIN
FRAMINGHAM, MASSACHUSETTS

A. PERTINENT DATA

1. Pertinent Data -

FLOOD WALLS

At Saxonville Pond	Gravity Type, Concrete
Top elevation	155.2 msl
Length	170 feet
Maximum height above adjacent ground surface.	6 feet
Stations 0/00 to 2/00	L-Type, reinforced concrete
Top elevation	138.0 msl
Maximum height above streambed.	18 feet
Stations 2/00 to 6/50	T-Type, reinforced concrete
Top elevation	137.0 msl
Maximum height above streambed.	22 feet
Stations 19/20 to 21/80	T-Type, reinforced concrete
Top elevation	136.5 msl
Maximum height above adjacent ground surface.	13 feet
Stations 22/60 to 23/90	I-Type, reinforced concrete
Top elevation	136.0 msl
Maximum height above adjacent ground surface.	10 feet

DIKE

Type	Earthfill with stone protection
Top elevation	Varies 137.0 to 134.5 msl
Top width	12 feet
Maximum height above streambed	23 feet
Slopes	Riverside 1 on 2.5; Landside 1 on 2 and 1 on 2.5
Total length	2,500 feet

CHANNEL REALIGNMENT

Length	1000 feet
Bottom width	60 feet
Side slopes	1 vertical on 2.5 horizontal

B. INTRODUCTION

2. Location and Description of Project - The Saxonville Local Protection Project is located on the Sudbury River, a tributary in the North Nashua River Basin, in the village of Saxonville which is situated in the northeasterly part of Framingham, Mass. It is a flood control project consisting of earth fill dikes and concrete flood walls along the left bank of the Sudbury River. In addition, the left abutment of Saxonville Pond Dam will be raised 6 feet by the construction of a gravity-type concrete wall and new gate structure. The locations, arrangements and details of the structures are shown on Plates 4-1 thru 4-5.

3. General Notes - Programs of subsurface investigations and soils engineering studies were undertaken for the design of the Saxonville Local Protection Project. The subsurface investigations included geological studies, subsurface explorations and laboratory test programs carried out to determine the distribution and characteristics of foundations and embankment materials and to determine soil conditions relevant to excavation operations and the design and construction of the embankments and concrete structures. Soils engineering studies, based on the data obtained from the subsurface explorations were conducted to develop safe and economical earthwork and foundation designs and construction methods.

4. Elevations - All elevations mentioned in this report are in reference to mean sea level.

C. SUBSURFACE INVESTIGATIONS

5. Geological Studies - The results of the geological studies including Site Geology are presented in Design Memorandum No. 2, Phase II - General Design, approved 5 September 1974.

6. Subsurface Explorations - Subsurface explorations were laid out and completed in conformance with current criteria and practices as described in Corps of Engineers Manuals EM 1110-2-1801, "Geological Investigations" and EM 1110-2-1803, "Subsurface Investigations - Soils". Most of these explorations were drive sample borings made with continuous sampling using a 5-foot solid sample spoon. Six auger borings were taken by hand methods, four of them to determine the characteristics and extent of the materials from the required excavations of the channel realignment.

One pit was excavated by hand methods to determine the character of the materials in an existing low spoil dike. This low dike (approx. Sta. 8+00 to Sta. 16+00) was formed by side casting methods when the river was dredged following the 1955 flood. Three borings were cored from within Mill Bldg. No. 3 to explore the stone foundation of this building and to determine if the foundation rests on bedrock. Sketches and results of these borings are shown on Plate 4-8. Thirty-five hand probings were also taken, the results of which are summarized in Appendix B. The subsurface exploration program is considered adequate for design and construction control purposes. The locations of the explorations are shown on Plates No. 4-2 thru 4-5.

7. Laboratory Tests - All laboratory tests were performed in accordance with the procedures described in Corps of Engineers Manual EM 1110-2-1906, "Laboratory Soils Testing". All soil samples were visually classified in accordance with the Unified Soil Classification System. Grain size analyses and Atterberg Limit determinations were performed on selected samples to confirm the visual classifications and to provide more precise data where required.

8. Presentation of Data - The results of the subsurface investigations, except for the geological sections, are presented in this memorandum. The results of the laboratory tests are summarized in Appendix A. Selected laboratory test data are shown on Plates 4-9 thru 4-11. Soil profiles for the project foundations, based on engineering soil reports, are shown on Plates 4-6 and 4-7. These soil reports were prepared for all pertinent explorations by the design soils engineer with the aid of the laboratory test data and the assistance of an experienced soils classifier. These reports include descriptions of the soils and soil strata based on the engineer's examination of the samples and his interpretation of the test results and the exploration data. These descriptions cover the state or consistency of a soil, estimated or measured percentages of soil components, color, stratification, presence of foreign matter, geological names, and other information of significance to the determination of the characteristics of a soil for design and construction purposes.

D. CHARACTERISTICS OF DIKE AND WALL FOUNDATION MATERIALS

9. Distribution and Description of Materials -

a. General - The floodwalls and dikes will be constructed in the flood plain of a river which is typified by broad marshes and flood plain deposits. The area inside the U-shaped river meander includes old river channels and marshy areas that have been filled with a variety of materials either by natural processes or artificially. Since about 1860 when the first mill buildings were constructed, the area has been undergoing intermittent artificial filling. The area downstream of the Concord St. Bridge is the site of an Urban Renewal Project with many of the buildings in various stages of being dismantled.

b. <u>Projected Topographic Conditions</u> - With the continual filling of the marshy areas and the dismantling of the buildings downstream of the railroad tracks, the topographic conditions in portions of the site are in a fluid state and are expected to remain so until the property is acquired from the present owners. For the purposes of design, it has been assumed that at the start of construction, the dike foundation from Sta. 6+50 to 19+20 will be approximately el. 124, except for the marshy area between Sta. 14+50 and 17+50. It is unlikely that the present owners will continue filling much above this elevation, nor that Urban Renewal Authorities will permit much filling other than for old cellar holes. It is planned to resurvey these portions of the site prior to construction.

c. <u>Subsurface Water</u> - Subsurface water levels in the floodwall and dike foundation areas fluctuate with the level of the adjacent river. Subsurface water levels in the foundation area of the existing Saxonville Pond Dam appear to fluctuate with the level of the adjacent pond.

d. <u>Foundation Zones</u> - As indicated by the soil profiles on Plates 4-6 and 4-7, the foundation soils occur in three fairly distinct zones which are designated in order of depth as Zones I, II and III. Zone I is a relatively thin surficial zone of variable soil types ranging from trash to granular fill materials and including natural soils under the artificial fills. Zone II is a zone consisting of a heterogeneous mixture of glacial lake deposits (silts and fine sands), glacial fluvial gravels and alluvial sands and gravels. Zone III is the lowest zone and consists mainly of variable gravelly silty sands (glacial till). In general, these zones are horizontally continuous.

(1) <u>Stations 0+00 to 6+50 (Floodwall)</u> - Zone I in the foundation area of the floodwall, occurs downstream of Sta. 1+50, is from 1 to 10 feet thick extending from the present ground surface down to about existing riverbed level (el. 119 to 115). Materials in this zone are principally granular fill materials containing minor to moderate amounts of cinders, brick, asphalt, coal fragments and similar foreign matter. These materials consist of brown to black, loose, gravelly silty sands (SM). Gravel contents are generally less than 25 percent. Silt contents of these soils range from 20 to 35 percent of the component passing the No. 4 Sieve. In the reach between Sta. 6+00 and 6+50 these artificial fills overlie 4 feet of brown to dark brown, loose, non-plastic, sandy silt (ML) and silty m-f sand (SM) containing variable amounts of organic material.

In the vicinity of Sta. 5+00 a 2.5 foot layer of organic silt is visible at the ground surface. These Zone I layers will be removed as part of the foundation preparation for the wall and wrap around portion of the dike.

Zone II in this reach is from 1 to 17 feet thick with its top surface varying from about el. 119 near Sta. 0+00 to el. 115 at Sta. 6+50. This material consists mainly of gray to gray brown, moderately compact, silty sandy gravel (GP-GM and GM) with cobbles. These gravels occur as a very thin veneer covering the streambed along Mill Bldg. No. 3 and thickening to 10 feet at Sta. 6+50 (FD-2). Silt contents range from 10 to 30 percent of the component passing the No. 4 Sieve. Underlying this gravel layer at about Sta. 6+50 is 7 feet thick of glacial lake deposits consisting of fine sands and silts.

Zone III (glacial till) is from 1 to 10 feet thick with its top surface above el. 116 between Sta. 0+00 and 3+50 and dipping to el. 98 at Sta. 6+50. Its bottom surface is defined by the bedrock surface which outcrops upstream at the base of the Saxonville Pond Dam and under the right abutment of the bridge, and dips to below el. 95 at Sta. 6+50. Zone III consists mainly of brown to gray, compact, gravelly silty sand with occasional cobbles. Gravel contents range from 5 to 30 percent. For the most part, silt contents range from 25 to 45 percent of the component passing the No. 4 Sieve.

(2) <u>Stations 6+50 to 19+20 (Dike)</u>- A large part of the foundation area for the dike is occupied by a U-meander of the river. Inside the flat area of this meander, Zone I is mainly composed of artificial fills, varying in thickness from 2 to 6 feet, overlying dark brown to gray, loose silty fine and m-f sand, fine sandy silts containing varying amount of organic material. In some areas the fills are underlain by organic silts as thick as 2 feet. In the marshy depression at the base of the U-meander, in the vicinity of the Pumping Station, a boring taken by others for the Sewer Force Main crossing encountered 3.5 feet of "peat" above el. 114.

Fill materials in this zone consist of loose mixtures of coal, ashes, cinders, bricks, lumber, concrete and other trash materials with silt, sand and gravel particles. Intermittent filling operations are continuing in this area, notably in the reach between Sta. 17+50 and 20+00. The bottom surface of the underlying silts and fine m-f sands is generally above el. 114. These materials contain variable amounts of organic materials in the form of roots, hair roots, wood fibers and decomposed organics. Silt contents of the silty fine sands range from 25 to 45 percent while those of the silty medium to fine sands range from 10 to 40 percent. At the east end of this reach, the silts and fine sands are replaced by brown, loose, gravelly sands (GP)

Zone II in this reach varies in thickness from 10 feet to over 18 feet. As indicated by the soil log profile and sections on Plate No. 4-6, the distribution of the various soil types in this zone of the dike embankment area is quite complex. The soil types are a mixture of gray, moderately compact, glacial fluvial sands and gravels; gray brown to gray, loose, alluvial gravelly sands; and glacial lake deposits of gray brown, loose to moderately compact, somewhat stratified, non-plastic silts and fine sands. Silt contents of the gravels range from 10 to 20 percent of the component passing the No. 4 Sieve. The gravel contents of the sands range from 8 to 30 percent while silt contents range from 5 to 25 percent of the component passing the No. 4 Sieve. The fine sandy silts contain from 10 to 40 percent fine sand while the fine sands contain from 15 to 35 percent silt.

The top surface of Zone III (Glacial Till) in this reach is generally below Elev. 100 but rises to Elev. 110 near Sta. 18⁄00. Soils in this zone consist of gray, moderately compact to compact, non-plastic, gravelly silty sand and silty sandy gravel. Gravel contents of the sands are generally less than 25 percent. Silt contents of the sands and gravels range from 25 to 35 percent of the component passing the No. 4 Sieve. The bedrock surface is generally below Elev. 95 but rises to about Elev. 100 near Sta. 18⁄00.

(3) Stations 19⁄20 to 23⁄90 (Flood Wall, Street Gate and I-Wall) - Zone I in the foundation of the Floodwalls and the Vehicular Gate Structure is from 10 to 15 feet thick extending from the present ground surface down to about Elevs. 115 to 113. Materials in this zone consist principally of artificial fills overlying brown, dark brown and gray, loose, fine sandy silt (ML) and silty fine sand (SM) with hair roots. Silt contents of the silty fine sands range from 20 to 40 percent while the silts contain from 10 to 40 percent fine sand. There are also occasional thin layers of silty sandy gravel (GP-GM, GP) intermingled with the silts and fine sands. Upstream of the Gate Structure, a thin layer of topsoil lies between artificial fills and silts. The artificial fills in this zone consist of a loose to compact mixture of coal, cinders, ashes, wood and other foreign materials mixed with silt, sand and gravel. The more recent fills from Sta. 17⁄50 to Sta. 20⁄00, which are the extension of the parking lot adjacent to a tavern, contain coarser and more foreign material in the form of concrete slabs and lumber scraps.

In this reach, Zone II varies in thickness from 10 to over 25 feet and is composed mainly of gray, loose to moderately compact, non-plastic, fine sandy silt (ML) with layers of silty fine sand (SM) and occasional clay laminae. The sandy silts contain from 5 to 40 percent fine sand.

Zone III in this reach varies from 2 to over 10 feet in thickness and is essentially of the same composition as in the previously described reaches. The top of bedrock is about elev. 95 at the upstream end of this reach and gently dips to below Elev. 85 at the downstream end.

(4) Stations 23⁄90 to 35⁄00 (Dike) - A large part of the foundation area for the dike in this reach is occupied by the existing riverbed. In this reach, Zone I is present intermittently and generally consists of a foot of silt or debris. Inland from the riverbed, however, Zone I is about 10 feet thick extending from the present ground surface down to about Elev. 113 and includes a recently abandoned lumber yard whose operating procedure included dumping scraps of lumber and other building materials along the banks of and into the river. Materials in this zone consist predominantly of loose mixtures of lumber scraps, ashes, cinders, coal, brick fragments, other foreign material and silt, sand and gravel particles.

At the downstream end of the project, these artificial fills directly overlie Zone III glacial till materials.

Zone I materials in the channel realignment area consist of dark brown and gray brown, loose, fine sandy silts (ML) and silty fine sands (SM) containing variable amounts of organic matter interspersed with pockets of organic silt (OL).

Zone II varies in thickness from 10 to over 20 feet and again as indicated by the soil profile, the distribution of the various soil types in this zone is quite complex. The distribution is somewhat similar to that between Stations 6+50 to 19+20, with a mixture of gray, loose to moderately compact glacial fluvial deposits of sandy gravels (GP) and glacial lake deposits of gray, moderately compact, non-plastic, fine sandy silts (ML) with layers of brown silty fine sands (SM). Silt contents of the gravel range from 5 to 15 percent of the component passing the No. 4 Sieve while the silts and fine sands are essentially the same with respect to composition as in the previously described reaches.

Zone III consists principally of a sandy glacial till deposit overlying an irregular bedrock surface. This deposit is essentially the same with respect to composition as in the previously described reaches.

10. Shear Strength - No samples of foundation materials for this project were tested for shear strength. The shear strength parameters tabulated below have been estimated on the basis of visual examination of the samples and their grain-size distribution curves, data from subsurface exploration logs and experience with similar materials. These parameters are considered to be applicable for all conditions considered within the anticipated ranges of applied stresses.

FOUNDATION ZONE	ESTIMATED SHEAR STRENGTH PARAMETERS	
	Ø	C
Zone I		
Artificial Fills	Not Applicable (to be removed)	
Silty Sands & Silts	25°	0
Organic Silts	0	500 to 1000 psf*
Zone II		
Gravels & Gravelly sands	30 - 35	0
Stratified Sands & Silts	25 - 30	0
Zone III		
Glacial Till	30°	0

*Applicable only to possibly continuous horizontal layers of organic silt.

11. Permeability - No permeability tests were performed on samples of foundation materials for this project. The ranges of coefficients of vertical permeability tabulated below have been estimated on the basis of visual examination of the samples and their grain-size distribution curves and experience with similar materials. It is estimated that the ratios of horizontal to vertical permeabilites will range from 4 to 16. As indicated below, the dike foundation materials in Zone I are less pervious than those in the underlying Zone II gravels and gravelly sands.

FOUNDATION ZONE	Kv ($\times 10^{-4}$ cm/sec)
Zone I	
Artificial Fills	Not Applicable (to be removed)
Silty Sands & Silts	1 to 50
Zone II	
Gravels & Gravelly Sands	5 to 200
Stratified Sands & Silts	0.5 to 25
Zone III	
Glacial Till	0.1 to 5

12. Consolidation - Consolidation tests were not performed on samples of foundation materials for this project. With the exception of the Zone I trash fill materials, organic silt layers and Zone II glacial lake deposits, the dike foundation materials are of the types exhibiting low compressibility. All trash fill materials and organic silt layers (within 3 feet of existing ground surface) under the riverside slopes of the dikes will be removed from the foundation areas of the dikes. While the materials in the remaining Zone I organic silt layers in certain reaches are compressible, the layers are relatively thin and are generally surrounded by more pervious soils. Artificial fills composed mainly of granular materials containing minor amounts of foreign material, will be left in place. Settlement due to consolidation of these layers and fill consequently are expected to occur principally during embankment construction. Where the depths of Zone II silts are substantial, it is anticipated that the maximum foundation settlement at the centerline of the dike will be less than 4 inches and that most of this settlement will occur during construction.

E. CHARACTERISTICS OF FOUNDATION BEDROCK

13. General - Bedrock outcrops are found upstream of Station 0+00 below Saxonville Pond Dam and the Central Street Bridge. Bedrock surface along the alignment found by borings is shown on Plates 4-6 and 4-7. The bedrock is a fine grained, moderately hard, greenish gray chloriticschist. The rock is foliated and has some argillaceous zones. The foliation varies from well developed planes dipping about 45 to 50 degrees to faint indistinct lines dipping at low angles. From outcrops the foliation dips upstream. There are occasional joints, most of which are parallel to the foliation. Sericite and calcite sometimes occur on the joint surfaces. Generally the rock is unweathered except in fractured zones in the upper few feet and along some joints. The rock is competent and is considered adequate foundation material for the structures in this project. The L-type wall at Station 0+00 to 2+00 and part of the T-type wall from Station 2+00 to 3+20 are to be founded on bedrock.

14. Bedrock Foundation -

a. For L-Type Flood Wall - The L-type wall from Station 0+00 to Station 2+00 will have its base at Elev. 115.5 or at Elev. 117.0. Boring FD-16 at about Station 1+65 encountered rock at about Elev. 117 (Plate 4-8) and penetrated about 17 feet into rock. The general rock surface elevation is shown on Plate 4-6. Because the rock is foliated and the foliation dips upstream at steep angles, the actual rock surface is expected to be highly irregular. Rock removal and filling of depressions with concrete will be required to establish a maximum base surface for the flood wall at Elev. 117.0 or Elev. 115.5. Rock removal may be accomplished by line drilling and light blasting, with jack hammers, and by barring and wedging with hand tools.

b. For T-Type Flood Wall - The T-type flood wall extending from Station 2+00 to Station 6+50 will be founded on bedrock from Station 2+00 to Station 3+20. Boring FD-9, FD-10 and FD-11 define the bedrock profile beneath the flood wall. There is a drop in elevation of about 6 feet from boring FD-16 at Station 1+65 to boring FD-9 at Station 2+50. Plate 4-6 shows foundation conditions at Station 2+50.

The bottom of the flood wall will be at Elevation 109.5. Rock removal to this elevation will be required from Station 2+00, where rock is anticipated at Elev. 114, to about Sta. 2+70. Concrete fill will be required from there on to the angle point in the flood wall at Sta. 3+25. The bedrock surface is expected to be very irregular.

15. Bedrock Foundation for Concrete Wall - Borings FD-18 and FD-19 located near the intake structure between Central Street and Saxonville Pond Dam (Plate 4-7) show bedrock at Elevs. 133 and 139 respectively. Outcrops at the base of the dam indicate that the rock surface is very irregular.

F. DISTRIBUTION AND DESCRIPTION OF MATERIALS FROM REQUIRED EXCAVATIONS

16. General - The major excavations for this project are those for the floodwalls, the dike foundation drains, the riverside toes of the stone protection layers, the removal of certain Zone I materials and the channel realignment. All suitable materials from these and other excavations will be used to the extent practicable in the permanent work. These materials will be used in random fill zones in the embankments and in certain backfill zones for the floodwalls and concrete structures because of the great variation in soil types involved and their erratic distribution. Materials from the required excavation unsuitable for use in the random fill zones will be utilized to the extent possible as dumped waste fill material. Excess and unsuitable materials shall be removed from the site and spoiled in waste areas furnished by the town.

17. Floodwall Excavations -

a. Stations 0+00 to 6+50 - Excavations for the floodwall in this reach will be made primarily in Zones II and III materials consisting principally of silty sandy gravels and sandy gravels (GM, GP-GM) and gravelly silty sands (SM), glacial till, with cobbles. The random fill material from these excavations will be variable with silt contents ranging from 10 to 45 percent of the component passing the No. 4 Sieve and gravel contents of the sands ranging from 5 to 30 percent. Since these excavations in Zone II and III materials will be below the water table, it is expected that drying back of the glacial till materials will be necessary. Excavated materials from Zone I will be spoiled or used as dumped waste fill.

b. Stations 19+20 to 23+90 - Excavations for the floodwall, Vehicular Gate and I-Wall will be made primarily in existing fills (Zone I) and partially in Zone II fine sandy silt (ML) materials. The random fill materials from these Zone II excavations will have sand contents ranging from 5 to 40 percent. Although these Zone II excavations will be done in the dry, it is expected that some drying back of excavated materialswill be necessary. The excavations in Zone I fills will consist principally of a mixture of coal, cinders, ashes, wood and other foreign materials mixed with silt, sand and gravel materials. Materials from these excavations will be spoiled or used as waste fill.

18. Dike Excavations -

a. Stations 6+50 to 19+20 -

(1) Dike Foundation - The major portions of the excavations in the foundation of the dike in this reach will be made for the removal of Zone I materials consisting of weak and compressible trash materials and silty fine sands and fine sandy silts containing variable amounts of organic matter. Materials from these excavations will be spoiled or used as waste fill.

(2) Foundation Drain - The excavations for the foundation drain in this reach will be made in highly variable deposits (Zone II) of gravelly sands (SP, SP-SM), gravelly silty sands (SM), sandy gravels (GP-GM) and stratified non-plastic silts (ML) and fine sands (SM) portions of which contain very minor amounts of organic materials in the form of wood fibers, and hair roots and pieces of wood. Although the mixing of various layers during excavation will result in the excavated random fill materials being more homogeneous, it will still be variable with the bulk of the material having silt contents ranging from 5 to 25 percent of the component passing the No. 4 Sieve and gravel contents ranging from 8 to over 50 percent. In certain reaches, particularly near the bottom of foundation drains, the excavated material may consist entirely of sandy silt (ML) and silty fine sand (SM). The foundation drain excavations will be done in the dry and no problems involving excessive water contents are anticipated for the bulk of the excavated material.

(3) Stone Protection Layers - The excavations for the riverside toes of the stone protection layers along the river will be made in deposits (Zone II) similar to those in which the foundation drain will be excavated. These excavations will be done in the wet and it is expected that drying back of some of the excavated materials will be necessary.

b. Station 23+90 to 35+00 -

(1) Dike Foundation - The excavations in the foundation of the dike in this reach will be made for the removal of the Zone I materials above the existing riverbed consisting of weak and compressible trash fills and about a foot of river bottom deposits of mud and debris. Materials from these excavations will be spoiled.

(2) Foundation Drain - Excavations for the foundation drain between Sta. 24+00 and 26+00 and Sta. 33+10 and 35+00 will be made in man-made fills consisting of gravelly silty sands (SM) containing various amounts of foreign material in the form of cinders, coal, brick and glass fragments.

Adjacent to the railroad between Sta. 24+00 to 26+00, the amount of foreign material varies from about 10 to 30 percent while downstream of Sta. 33+10 the fills consist of a mixture of silt sand and gravel particles with cinders, coal and brick fragments. Materials from these excavations will be spoiled or used as waste fill.

(3) Stone Protection Layers - The excavations for the riverside toe of the stone protection layers along the river will be made in highly variable deposits (Zone II) of sandy gravels (GP), gravelly silty sand (SM) and fine sandy silts (ML). The excavated random fill material will be variable with the silt contents of the sands and gravels ranging from 5 to 20 percent of the component passing the No. 4 Sieve. Gravel contents of the sands range from 5 to 25 percent. In certain reaches, the excavated materials may consist entirely of sandy silt (ML). These excavations will be done in the wet and it is expected that drying back of some excavated materials will be necessary.

(4) Channel Realignment - The upper portions of the excavations for the new channel will be made in Zone I materials consisting of fine sandy silts (ML) and silty fine sands (SM) containing variable amounts of organic matter and interspersed with pockets of organic silt. The lower portion of these excavations will be in deposits similar to those in which the stone protection layers will be excavated. These excavations will be done pattially in the wet and separation of materials is not practicable. Because of the small quantity of material involved and the impracticability of separating materials, all materials from this excavation will be spoiled.

G. CHARACTERISTICS OF EMBANKMENT MATERIALS

19. General - The quantity of suitable embankment material available from the required excavations for the project will be only a small part of the total quantity of materials needed to complete the embankments. Reference is made to approved Design Memorandum No. 2, Phase II - "General Design" for a discussion of off-site sources of embankment materials. In view of the relatively high cost of developing government-furnished borrow areas and the complications involved in acquiring land for borrow areas, it has been decided to have the contractor furnish all embankment materials other than those available from the required excavations.

20. Filter Design - The gradation requirements for sand, gravel, processed gravel and filter sand fill materials and for gravel bedding materials have been established in accordance with the filter design criteria set forth in Engineering Manual for Civil Works Construction, EM1110-2-1901, "Seepage Control". Typical filter design studies are shown on Plates No. 4-15 and 4-16.

21. Random Fill - The suitable embankment material from the required excavation will include a wide range of soils - from sandy gravels to silty fine sands and fine sandy silts. In view of the variablity of the material and the impracticability of separating the various soil types during construction, it is planned to use the material in random fill zones in the embankments and for certain backfill zones for the floodwalls and other concrete structures. Random fill material will not contain significant quantities of cinders, ashes, topsoil and similar matter and shall be free of stumps and large pieces of debris. For design purposes, the densities, permeability coefficients and shear strength parameters selected for impervious fill material have been used for the random fill material.

22. Impervious Fill - Impervious fill material will be furnished by the contractor and will consist of approved, natural, reasonably well graded, gravelly silty sand. The gradation of the material will be required to be such that from 50 to 95 percent of the component passing the 3-inch Sieve will pass the No. 10 Sieve and from 25 to 45 percent of the component passing the No. 4 Sieve will pass the No. 200 Sieve. It is estimated that compacted impervious fill material will have an average coefficient of permeability of less than 1×10^{-4} cm/sec and will develop shear strength parameters in excess of a $\emptyset = 32$ degrees, envelope within the anticipated applied stress range for all conditions considered. Experience with similar materials on other projects indicates that placement moisture content can be maintained within 2 percentage points of optimum with moderate moisture control and that in-place compacted dry densities will be on the order of 120 p.c.f.

23. Sand Fill - Sand fill material will consist of either processed sand fill material as specified in Paragraph 26 or approved bank-run reasonably well graded gravelly sand furnished by the contractor. The bank-run material will be required to meet the following gradation limits:

Sieve Size (U.S. Standard)	Percent Passing by dry weight
3-inch	100
No. 4	70-95
No. 10	50-85
No. 50	10-40
No. 200	0-8

(In addition, not more than 3 percent, by dry weight, shall be finer than 0.01 mm).

It is estimated that compacted sand fill material will have an average coefficient of permeability exceeding 100×10^{-4} cm/sec and will develop an angle of internal friction of at least 32 degrees.

24. Gravel Fill - Gravel fill will consist of approved contractor furnished material reasonably well graded within the following limits:

Sieve Size (U.S. Standard)	Percent Passing by dry weight
6-inch	100
1-inch	50-80
No. 4	30-60
No. 16	15-40
No. 200	0-5

(In addition, not more than 3 percent, by dry weight, of the component passing the No. 4 Sieve shall be finer than 0.01 mm). It is estimated that compacted gravel fill material will have an average coefficient of permeability exceeding 200×10^{-4} cm/sec and will develop an angle of internal friction of at least 32 degrees.

25. Processed Gravel Fill - Processed gravel fill will consist of contractor furnished material meeting all State of Massachusetts specification requirements for coarse concrete aggregate in the No. 4 to 3/4 inch size range. It is estimated that compacted processed gravel fill material will have an average coefficient of permeability on the order of $10{,}000 \times 10^{-4}$ cm/sec. The gradation range is shown on Plate 4-13. The material will be required to meet the following gradation limits:

Sieve Size (U.S. Standard)	Percent Passing by dry weight
3/4 inch	90-100
3/8 inch	20-50
No. 4	0-10
No. 8	0-5

26. Processed Sand Fill - Processed sand fill will consist of contractor furnished material meeting the State of Massachusetts specification for fine concrete aggregate. It is estimated that compacted processed sand fill material will have an average coefficient of permeability in excess of 500×10^{-4} cm/sec. The gradation range is shown on Plate 4-13. The material will be required to meet the following gradation limits:

Sieve Size (U.S. Standard)	Percent Passing by dry weight
3/8 inch	100
No. 4	95-100
No. 16	55-80
No. 50	10-25
No. 100	2-8
No. 200	0-2

27. Gravel Bedding - Gravel bedding will consist of approved contractor furnished material reasonably well-graded within the following limits:

Sieve Size (U.S. Standard)	Percent Passing by dry weight
6-inch	100
1-inch	50-80
No. 4	30-65
No. 16	15-40
No. 200	0-5

(In addition, not more than 3 percent, by dry weight, of the component passing the No. 4 Sieve shall be finer than 0.01 mm).

H. DESIGN OF DIKES

28. Criteria - Current design criteria as set forth in the pertinent sections of the Engineering Manual for Civil Works Construction No. 1110-2-2300, "Earth Embankments" and the regulations and bulletins referred to therein have been followed in the design of the dikes for this project.

29. Materials for Embankment Construction -

a. Materials from required excavations - It is estimated that there will be about 93,000 cubic yards of required excavations for this project. Of the materials from these excavations, about 13,000 cubic yards will be suitable for use in the random fill zones of the dikes and for certain backfills around concrete structures. The remaining 80,000 cubic yards of material will consist in large part of cinders, ashes, trash fill, and stripping material and will be utilized to the extent possible as dumped waste fill. All suitable material from the required excavations will be used either in the embankments or in certain backfill zones for the concrete structures.

b. Materials Furnished by the Contractor - All dike materials other than random fill material will be furnished by the contractor from off-site sources.

c. Materials Usage - A chart showing the proposed utilization of materials from the required excavations and of materials furnished by the contractor is shown on Plate 4-20. The quantities shown are subject to change as more detailed quantity estimates are developed during the preparation of plans and specifications for the project.

30. Selection of Dike Sections - The sections for various reaches of the dikes developed as a result of design studies are shown on Plates 4-17 thru 4-19. The selection of the sections was influenced by the foundation conditions, the availability and characteristics of embankment materials, seepage control requirements, stream erosion and construction considerations. In general, the embankments will consist of a large zone of compacted impervious fill, a smaller zone of compacted random fill, a landside zone of compacted sand fill and a landside toe drain to compacted gravel fill or compacted sand fill. The embankment will be protected by layers of stone protection and gravel bedding on the riverside slopes and by seeded topsoil on the landside slopes except for limited stone protection layers at the toes.

31. Seepage Control -

a. Seepage Through Dike - Seepage through the dikes will be controlled through the arrangement, sizes and differences in permeabilities between the impervious fill zone and those of the landside sand fill and gravel fill zones.

b. Foundation Seepage -

(1) General - In view of the moderately high hydraulic heads anticipated in the reach of the dike from Sta. 6+50 to Sta. 19+20 and the presence of many pervious foundation deposits overlain by less pervious material, considerable attention was given to the design of the foundation seepage control features for the dike in this reach. No continuous foundation zone of suitable impervious soil exists in the dike foundation to which an impervious foundation cut-off could be extended. Foundation seepage control for the dikes therefore has been based on providing landside drainage facilities of sufficient capacity to prevent the development of detrimental seepage pressures beneath the less pervious upper soil strata. Where practicable, these facilities consist of foundation toe drains extending into the pervious foundation strata. In the reach from Sta. 24+00 to Sta. 35+00 where the hydraulic heads are low, less than 10 feet, a shallow toe drain has been provided to intercept seepage and prevent softening of the landside toe.

(2) Dike (Sta. 6/50 to Sta. 19/20) - In this reach of the dike, the top of Zone II materials is generally below elev. 114 except from about Sta. 17/50 to Sta. 19/20 where the top of this zone rises above elev. 118. With the bottom elevation of the foundation drain, between Sta. 6/50 and Sta. 17/50, varying between elev. 108 and elev. 110, the foundation drain will extend into the hetergeneous Zone II materials by 4 to 6 feet. With a bottom elevation of 112 between Sta. 17/50 and 19/20, the foundation drain in this reach will extend into Zone II by at least 6 feet. The drain itself will consist principally of compacted sand fill with a perforated pipe drain and processed gravel filter. The pipe drain is included between Sta. 6/50 and Sta. 19/20 to prevent the landside toe from becoming saturated and soft in the event that the toe becomes silted up blocking drainage and to even out the hydraulic gradient resulting from hetergeneous foundation conditions.

(3) Dike (Sta. 24/00 to Sta. 35/00) - The excavation for the removal of the trash fill from the dike foundation between Sta. 26/00 and Sta. 33/10 will uncover most of the hetergeneous Zone II foundation materials. The top of this zone is generally below elev. 113. Because the hydraulic heads are low, less than 8 feet, the foundation drain will only extend 2 feet below finished grade at the landside toe in this reach. The hydraulic heads along the remainder of the reach are generally less than 6 feet. A shallow toe drain is provided to prevent softening of this area as well as removing some of the weaker surficial fill material. These shallow drains will consist of compacted gravel fill material.

c. Contacts with Concrete Structures - At the junctions of the embankments with concrete structures, impervious fill material will be carefully compacted by special methods to produce a tight contact with the structure and a high fill density in the zone within which rolling compaction equipment cannot or should not operate. At the junctions of the concrete flood walls and the dikes, the normal T-wall - I-wall type connection will be used. An I-wall connection will also be used between the Concord St. Gate and the dike at Sta. 24/00.

32. Embankment Stability -

a. General - A Generalized section of the riverside portion of the dike, where the height of slope is about 23 feet and the foundation is assumed to contain a significant depth of Zone II silt materials, was selected for stability analysis as being a section combining a near maximum embankment height with significant layers of low shear strength. This section was analyzed for stability against shear failure by the circle method for the end of construction and sudden drawdown conditions.

b. Selection of Design Values - The design unit weights and shear strength parameters have been selected on the basis of experience with similar materials on other projects and are tabulated below:

Material	Unit Weight, p.c.f.				Shear Strength	
	Sat.	Moist	Dry	Sub	Ø	C
Stone Protection	140	--	120	78	40°	0
Gravel Bedding and Gravel Fill	145	140	130	83	35°	0
Comp. Impervious and Random Fill	140	130	120	78	32°	0
Comp. Sand Fill	140	130	120	78	30°	0
Foundation Silt and Silty Fine Sand	120	100	90	58	28°	0

c. Results of Stability Analysis - The minimum factors of safety for an assumed section of maximum height and significant depth of silt materials with Zone I materials removed are tabulated below. Similar analyses where the height of riverside slopes are about 14 feet in height indicate that 3 feet of Zone I materials must be excavated to give similar factors of safety. On the basis of the results of these analyses, it is considered that the selected embankment sections are safe against shear failure.

Condition Analyzed	Minimum Factor of Safety
Sudden Drawdown	1.03
End of Construction	1.40

33. Settlements - For the most part Zone II and III foundation soils are of low compressibility and no significant settlements are anticipated from these soils. In the reach of the dike between Station 7+25 and about 17+50, however, there are areas on the riverside of the dike in which the Zone I foundation will include layers and lenses of compressible organic soils. These layers and lenses are generally thin and interbedded with more pervious soils. It is expected that settlement due to the presence of these organic soils will occur almost entirely during construction and that no significant post-construction settlements will take place. All trash-fill materials and some of the Zone I organic soils under portions of the riverside slopes will be removed prior to construction of the dikes. In the reaches of the dikes between Stations 24+00 and 26+00, and Stations 33+10 and 35+00 where the artificial fills are composed mainly of granular materials containing minor amounts of foreign materials, portions of these fills will be left in place.

It is expected that settlements of these fills will also occur almost entirely during construction and that no significant post construction settlements will take place.

Where the depth of zone II silts are substantial it is anticipated that the maximum foundation settlement at the centerline of dike would be less than 4 inches and that most of the settlement will occur during construction.

34. Construction Considerations -

a. Dewatering Construction Areas - All areas in which compacted embankment fills are to be constructed will be dewatered. Along portions of the riverside toe of the dikes, there will be a gravel fill zone which will serve as a permanent cofferdam. The lower portion of this zone will be dumped into 3 to 4 feet of water while the upper 2 to 3 feet of the zone will be compacted. Elev. 119 is the river level for a 6 year frequency flood. The dumped gravel fill will be placed by end dumping and pushing to minimize segregation. It is anticipated that the dewatering of the construction areas, in general, will be possible by the usual methods of construction drainage including open pumping. In the excavation for the foundation toe drain for the dike, however, special methods such as well-pointing may be necessary. A maximum of 1-foot depth of water will be permitted in the bottom of the excavation for the foundation drain during the placement of the initial layers of sand fill.

Where the bottom of the excavation for the foundation of the dike, Sta. 26+00 to Sta. 33+30 and 40 feet each side of the conduit, could be in silts and fine sands, construction traffic could pump water to the surface making the bottom wet and spongy and incapable of supporting such equipment unless the ground water table is maintained at least 3 feet below the bottom of the excavation. In order to reduce the amount of dewatering an initial layer of 18 inch thickness of impervious fill may be required to assist in stabilizing the silt material and to provide a working floor for the construction equipment.

b. Rate of Construction - In general, the dikes will be constructed to their full width in reaches long enough to permit proper operation of compaction equipment. Exceptions will be made in certain reaches as required to facilitate direct utilization of random fill material from the required excavations. It will be required that prior to certain flood seasons, all partially completed dike reaches will be completed to their full width, including stone protection.

35. Methods of Placement and Compaction -

a. Spreading - Materials for fills shall be spread with bulldozers or other approved equipment or by hand to form uniform loose layers of the following thicknesses:

MATERIAL	MAXIMUM LOOSE LAYER THICKNESS IN INCHES	
	General	Restricted Areas
Comp. Impervious Fill	6	4
Comp. Random Fill	6	4
Uncomp. Random Fill	12	--
Comp. Sand Fill	8	4
Uncomp. Sand Fill	12	--
Comp. Gravel Fill	8	4
Uncomp., Processed Gravel Fill	8	--

b. Compaction - Materials for compacted fills shall be compacted as follows according to its fill type:

FILL TYPE	COMPACTION
Comp. Impervious	At least 6 passes of the tamping roller
Comp. Random (In dikes and Ramps)	At least 6 coverages of the tread of the heavy tractor.
Comp. Random (elsewhere)	At least 4 coverages of the tread of the light tractor.
Comp. Sand (In dikes)	At least 6 coverages of the tread of the heavy tractor or at least 3 passes of the vibratory roller.
Comp. Sand (Elsewhere)	At least 4 coverages of the tread of the light tractor.
Comp. Gravel	At least 6 coverages of the tread of the heavy tractor or at least 3 passes of the vibratory roller.

c. Compaction in Restricted Areas - In restricted areas impervious fill shall be compacted by at least 4 coverages of the tamping foot of the power tamper. Random, sand and gravel fill in a restricted area shall be compacted by the plate vibrator.

d. Equipment - Compaction equipment shall conform to the following requirements and shall be used as prescribed in subsequent paragraphs.

(1) Heavy Tractor - A "heavy tractor" to be used for compacting fill material shall be a standard commercial make crawler type tractor weighing not less than 35,000 pounds and exerting a tread pressure of not less than 9 pounds per square inch. The tractor shall be equipped with standard width treads.

(2) Light Tractor - A "light tractor" to be used for compacting fill material shall be a standard commercial make crawler type tractor weighing between 7,500 and 12,000 pounds and having a width of 5-½ feet or less, measured between the outside edges of the crawler tracks.

(3) Tamping Roller - A tamping roller shall consist of a double drum unit with a drum diameter not less than 40 inches and an individual drum length of not less than 48 inches. The drums shall be water or sand and water ballasted. The weight of the roller shall not be less than 1,000 pounds per foot of linear drum length weighted.

(4) Vibratory Roller - A vibratory roller shall be an approved unit designed for the compaction of soil by vibration and shall be the product of a manufacturer nationally recognized for the design and production of such equipment. The roller shall have a single drum having a diameter of 30 inches or more and a width of 54 inches or more. The roller shall weigh more than 700 pounds per foot of drum width and shall be towed by a tractor at a speed of not more than 1 mile per hour. The tractor shall have a drawbar so constructed that the roller can be towed with a side draft if the width of the tractor is greater than that of the roller. The side draft method shall be used in areas inaccessible to the roller when towed directly behind the tractor.

(5) Power Tamper - A power tamper shall be an approved pneumatic or mechanical tamper designed for the compaction of soils and the product of a manufacturer nationally recognized as a specialist in the design and manufacture of such equipment. Jackhammers or similar equipment not specifically designed for the compaction of earth material will not be approved. The tamper shall deliver no more than 1,000 blows per minute and in addition shall have a circular tamping foot not more than 6 inches in diameter and shall be of a type that can operate satisfactorily at angles of up to 45 degrees to the vertical.

(6) Plate Vibrator - A plate vibrator shall be an approved plate surface vibrator designed for the compaction of soils by vibration and the product of a manufacturer nationally recognized as a specialist in the design and manufacture of such equipment. The surface contact plate shall be between 15 and 18 inches in width.

36. Slope Protection -

a. Hydraulic Design of Riprap - The hydraulic analysis for riprap design was presented in Design Memorandum No. 1, "Saxonville Local Protection," dated December 1972. This analysis has been reviewed in response to OCE comments and the data presented in Design Memorandum No. 1 are considered appropriate for design of the riprap revetment. The OCE comments pertaining to this analysis are contained in the 1st Indorsements to Design Memorandum No. 1 and to Design Memorandum No. 2, "General Design - Phase II," dated 23 February 1973 and 5 September 1974, respectively.

The basic tractive force formula states that the tractive force equals the product of the unit weight of water, the hydraulic radius or depth, and the friction slope: $\tau = \gamma RS$. Therefore, in any given channel, the tractive force, and required D_{50}, increases with increasing normal flow depth. Because of this relationship, this office cannot agree with Paragraph 2 of OCE comments dated 23 February 1973 or Paragraph 3d in ETL 1110-2-120, which suggest that conditions resulting in minimum flow depth and maximum velocity should be used for riprap design.

Backwater computations were rerun at Saxonville using lower assumed "n" values, resulting in slightly shallower depths which in-turn resulted in lower "D_{50}" requirements. The original computations based on conservatively high "n" values were therefore adopted for riprap design.

The 1.5 safety factor, introduced in Paragraph d (4) of ETL 1110-2-120, for non normal flow conditions, was not considered necessary at Saxonville and was not adopted. Based on experience in riprap design at NED using the tractive force principle, it is believed that wide spread adoption of such an arbitrary safety factor could result in considerable unnecessary over design of riprap. Before use of such a factor is made mandatory it is suggested that the tractive force principle of design be reviewed, continually keeping in mind that, according to this principle it is not the velocity or its distribution that determines the tractive force but, conversely, it is the tractive force that determines the velocity and its distribution. Further discussion of NED's application of the tractive force principle to riprap design is presented in: Design Memorandum No. 3, "Derby, Connecticut Local Protection" dated April 1968.

b. General - The riverside slopes of the dikes and the floodwalls will be protected from stream erosion by layers of stone protection and gravel bedding. The landside slopes of the dikes will be topsoiled and seeded except at the toe where Stone Protection will be placed to control seepage emerging from the toe drains. Design velocities and computed D_{50} minimum sizes, assuming unit weight of stone as 165 p.c.f., are presented in paragraph 36a, and in Design Memorandum No. 1, Hydraulic Analysis.

Four operating quarries within a 7 to 25 mile radius of the project were investigated as possible sources of stone protection material. These investigated indicated the smaller sizes, less than about 150 lbs., tended to be more elongated in shape rather than blocky while the reverse appeared to be true for the larger sizes.

Based upon experience with other projects and the results of the above mentioned investigations, it is concluded that the contractor will experience difficulty meeting the shape factor criteria specified in EM 1110-2-1601, Hydraulic Design of Flood Control Channels. Therefore the layer thicknesses for Classes I and II Stone Protection will be increased from 12 to 15 inches and from 14 to 18 inches repectively and the shape factors changed to the following criteria:

Elongation Ratio	Not to Exceed the Following Percent
1:5.0	0
1:4.0	5
1:3.0	15

The layer thickness, gradation range and other pertinent data are shown in the following table:

Class	Basic Layer Thickness (inches)	Percent Lighter by Weight (SSD)	Limits of Stone Weight, lbs.
		100	50 to 120
I	15	50	15 to 25
		15	<10
		0	2 min
II	18	100	50 to 200
		50	25 to 50
		15	<25
		0	2 min

I. PERMANENT CUT SLOPES

37. The only permanent cut slopes on the project will be along the left bank adjacent to the granite block railroad abutment and along the right bank of the channel realignment. The excavated slope along the left bank will vary from 1 on 2.5 to 1 on 2.

This slope will be provided with stone protection. To assure adequate stability, any trash fill materials behind this slope will be removed and replaced with dumped gravel and compacted impervious fill. The right bank of the Channel Realignment will be excavated to a slope of 1 vertical to 2.5 horizontal.

J. CONCRETE STRUCTURES - FOUNDATIONS, SEEPAGE CONTROL, SHEETING AND UNDERPINNING

38. Flood Wall Adjacent to Mill Building No. 3 - (Sta. 0+00 to 3+20) -

a. The flood wall will consist of L-type and T-type concrete walls as shown on Plate 4-3. The height of the walls in this reach varies from 18 to 22 feet above streambed. The L-type wall will be constructed along the riverside face of the existing mill building with a transitional change to a T-type wall as the wall alignment angles away from the building near Sta. 2+00. The L-type wall (Sta. 0+00 to 2+00) will be constructed within 3 feet of the face of the existing building and will be founded on bedrock. The T-type wall (Sta. 2+00 to 3+20) will also be founded upon bedrock, but at a greater distance from the building.

b. Mill Building No. 3 was built in 1910. It is three stories high with brick sidewalls and a pink granite block foundation. As shown on Plate No. 4-8, the riverside brick wall is about 2 feet thick. It is estimated that the building wall load ranges from 2½ to 3 tons per story per linear foot of building.

c. As stated in paragraph 6, 3 angle borings were drilled from within the building through the outer granite block foundation wall into bedrock. Geological and Soil sections are shown on Plate 4-8. These borings indicate that the bottom grade of the riverside granite block foundation wall is about el. 118, within 3 feet of the bedrock surface at Sta. 1+50 and within 7 feet at Sta. 2+50, el. 115.5 and el. 111 respectively. Bedrock is exposed under the dam 50 feet upstream of the north corner of the building and 60 feet across the river under the Central St. bridge abutment.

d. The foundation soil under the granite blocks in the vicinity of Sta. 1+50 appears to be a 3-foot leveling course of silt, sand and gravel size particles mixed with cobbles and boulders. The foundation soil under the granite blocks in the vicinity of Sta. 2+50 is a glacial till consisting of a gray brown to gray, compact, gravelly silty sand and silty sandy gravel containing cobbles and boulders.

e. In order to construct the flood wall in the reach from Sta. 0+00 to Sta. 2+50 without damage to the building from lateral movement of the soil, construction sheeting and underpinning will be installed between the building and flood wall. The sheeting will consist of soldier beams drilled and grouted into bedrock and horizontal lagging.

It will be specified in this reach wherever the bottom of the granite block foundation is more than 2 feet but less than 4 feet above the bedrock surface. After the river has been diverted for construction, the contractor will excavate a series of test pits along the building foundation to obtain additional information on the depth to bedrock and the bottom elevation of the granite block wall. This additional information will be used to establish the limits of this construction sheeting.

Consideration is also being given to an underpinning method consisting of digging approach and underpinning pits along the building, as required, between Sta. 0/00 and Sta. 2/50 where the depth from the bottom of the granite block foundation to bedrock is greater than 4 feet. The pits would be sheeted and their bottoms will range from 5 to 8 feet below adjacent streambed. After the pits have been excavated to rock and concreted to within 3 to 4 inches of the bottom of the granite block foundation, the remaining space will be wedged with dry packing.

f. Observations will be made at regular intervals to monitor any vertical or lateral movement of the building. In addition, the building will be thoroughly examined, including photographs, for any defects prior to sheeting.

g. As described in Paragraph 13, the bedrock dips in an upstream direction and the bedrock surface upon which the walls rest will be uneven. Two structural design sections (utilizing different anchor spacing) will be specified in this reach depending upon the elevation of the bedrock surface. One section will set maximum foundation grade at el. 115.5 while the other will specify el. 117.0 as the bottom of the L-wall. Bedrock surfaces falling below el. 115.5 will be brought to grade (el. 115.5) with concrete fill. Bedrock surfaces falling between el. 115.5 and el. 117.0 will be lowered to el. 115.5 or brought to el. 117.0 with concrete fill depending upon the most practicable and economical section. Bedrock surfaces above el. 117.0 will be lowered utilizing a combination of methods such as line-drilling with light charges, jackhammers, barring and wedging.

h. A landside drainage zone will be provided to control foundation seepage.

39. <u>Flood Wall Adjacent to Mill Building No. 4 (Sta. 3/20 to 5/25)</u> -

a. The floodwall in this reach will consist of a T-type concrete wall. The height of the wall adjacent to the building is 22 feet above streambed. The stem of the T-wall will be constructed within 3 feet of the face of the southwest corner of Building No. 4 and will consist of a sloping base wall founded on glacial till at heel el. 106.

b. Mill Building No. 4 (Dye House) was constructed about 1920. The building is three stories high but the first floor is open underneath to allow the dye hoppers to discharge into the Sudbury River. The second and third stories have brick side walls supported by I-beam sills resting upon 2-foot square brick piers spaced on 8 foot centers around the periphery of the building. The interior piers are 8 feet on center in rows 20 feet apart. It is estimated that column loads on the front wall could be as much as 40 tons per pier.

c. No information is available as to the depth of these footings; and after river diversion, the contractor will excavate test pits to determine the depth of footings. The earth foundation alongside the riverside face of the building consists of gray, moderately compact, silty sandy gravel (GP-GM, GM) (Zone II) overlying a glacial till (Zone III). The top surface of the till is at about el. 110 and consists of gray, compact, gravelly silty sand (SM). The allowable bearing pressure of the glacial till is estimated to be at least 4 t.s.f. while that of the sand and gravel is 3 t.s.f. The foundation materials upstream of this building consist of a fill of loose, gravelly silty sand containing cinders and ashes and other foreign material extending from ground surface to the top surface of the till. Downstream of this building about 3 feet of organic silt overlies the Zone II gravel.

d. In order to construct a T-wall adjacent to this building, the southwest corner will be underpinned utilizing needle beams or other methods of support. Alternate foundation designs for the T-wall monolith and the underpinning of the building are being studied. Those being considered are as follows:

(1) Founding both wall and piers on bedrock.

(2) Founding the flood wall on glacial till with the piers being supported on base of wall.

(3) Founding piers on bedrock and the wall on till with blockouts in the wall base for the piers.

e. A landside drainage zone will be provided to control foundation seepage.

40. Flood Wall adjacent to Mill Bldg. No. 11 (Sta. 5+25 to 6+00) -

a. The southwest corner of this building is within the required excavation for the T-wall in this short reach. This building was constructed prior to 1900, consists of two stories and is open underneath. The building has wood side walls supported by an I-beam sill resting on concrete piers. The corner piers are protected by a 4 foot high dry masonry wall.

No information is available as to the depth of the footings or the rubble wall; therefore, test pits will be made by the contractor after river diversion to determine the elevation of the bottom of footings and rubble wall.

b. Foundation conditions in this reach are generally similar to those adjacent to Mill Building No. 3. At the corner and behind the rubble wall, however, foundation materials include a fill of lose, gravely silty sand containing varying amounts of ashes, cinders, brick and asphalt fragments extending from the ground surface to about el. 120. This fill overlies about 4 feet of loose, nonplastic, sandy silt (ML) and silty m-f sand (SM) containing variable amounts of organic material. These slightly compressible materials are underlain by the moderately compact sands and gravels previously described in paragraph 9d.

c. Construction sheeting will be specified to protect the corner of this building. Vibrations from driving the sheeting could cause earth movement and settlement of the piers unless they are founded on consolidated material such as the sand and gravel layer or the glacial till. In the event that the corner piers are not founded on consolidated materials, the building loads will be transferred to a consolidated layer by underpinning methods such as needlebeams and blocking.

41. T-Wall-Station 19+20 to Sta. 21+80 -

a. As discussed in paragraph 9d(3), the foundation materials along this reach of wall include about 2 to 5 feet of fill extending from the ground surface to about el. 120. This fill overlies about 4 to 6 feet of slightly compressible, loose, non-plastic to slightly plastic, fine sandy silt (ML) and silty fine sand (SM) with hair roots. The underlying Zone II materials vary in thickness from 10 to 25 feet and are composed mainly of gray, loose to moderately compact, nonplastic, fine sandy silt (ML) with layers of silty fine sand (SM) and occassional clay laminae. The top surface of the Zone III glacial till is at a depth of 20 to 30 feet below the existing ground surface.

b. The T-wall will be a sloping base type with the heel at el. 110.5 and toe at el. 112.5 about 4 to 2 feet, respectively, below the top of Zone II.

c. The estimated loadings for the wall (max. net loading of 0.5 t.s.f. for case 1) are within the allowable range of 0.75 to 1.0 t.s.f. for such foundation materials and only minor settlement is anticipated.

d. The excavation for the flood wall will be from 2 to 4 feet below the bottom of the riverbed and 13 to 15 feet below the top of the landside slope. This excavation will be dewatered by vacuum dewatering methods.

e. A landside drainage zone will be provided to control seepage through the foundation of the structure.

42. Concord Street Flood Gate - As described in paragraph 9d(3) the foundation materials at the site for the gate include about 10 feet of fill consisting of a loose mixture of silts, sands and gravels with varying amounts of ashes, cinders, brick, wood and asphalt fragments, and other foreign material. This fill is underlain by a slightly compressible layer of about 3 feet of dark brown to gray, loose to moderately compact, non-plastic, sandy silt (ML) and silty fine sand (SM) with some organics. This layer overlies about 20 feet of loose to moderately compact, non-plastic, silty fine sand (SM) and fine sandy silt (ML) which in turn overlies about 6 feet of glacial till. Bedrock is at a depth of 40 feet below the road surface.

The base for the gate will be at el. 115 in loose to moderately compact non-plastic, fine sandy silt about 12 feet below street level and has been designed to tolerate slight differential settlements due to the anticipated consolidation of the silt material. The estimated loadings for the structure (max. net loading of 0.5 t.s.f. for Case 1) are within the allowable range (0.75 to 1.0 t.s.f.) for such foundation materials and about one inch of differential settlement is anticipated. A landside drainage zone will be provided to control seepage through the foundation of the structure.

The street gate excavation will be dewatered. This may require vacuum dewatering with well points to lower the ground water below the excavation.

43. Pumping Station -

a. Conduit and Gate Structure - The conduit will be a reinforced concrete cast-in-place box conduit with alignment collars at each joint. The foundation grades for the conduit and gate structure for the pumping structure will be at about elev. 112. At this depth, foundation soils could consist of the highly variable deposits (Zone II) of loose to moderately compact, gravelly silty sands (SM) gravelly sands (SP, SP-SM) or stratified, moderately compact non-plastic silts (ML) and silty fine sand (SM) or a combination of both. For the purposes of design it has been assumed that the foundation will consist of the more compressible silts and fine sands.

While materials in the silt deposit are more compressible, their rates of consolidation are such that practicably all settlements will occur during construction. Assuming a substantial thickness of silt material, it is anticipated that the maximum foundation settlement at the centerline of the dike will be less than 6 inches. Above about elev. 114, there are Zone I deposits of weak and compressible silty fine sands (SM) and fine sandy silts (ML) containing variable amounts of organic material. The presence of these soils in the foundation of the dike embankment could result in spreading which could open conduit joints and tip the gate structure. To avoid such a possibility, these materials will be removed from the entire dike foundation for a distance of 40 feet to either side of the conduit. The conduit will be sloped a sufficient amount to allow for any settlements.

b. Pumping Station Structure - The structure for the pumping station will be constructed at about Sta. 16+40 on the landside of the dike. Its foundation will be at about elev. 112 and will be on soils similar to those described in paragraph above. The estimated loadings for this structure are well within the allowable range of these materials. The foundation for the adjacent dike will be continued around the structure. Differential settlements of the foundation at the joint between the conduit and pumping station caused by the construction of the dike embankment are anticipated and a special joint will be designed to take the expected 1 to 2 inches of differential settlement.

44. Saxonville Pond Dam -

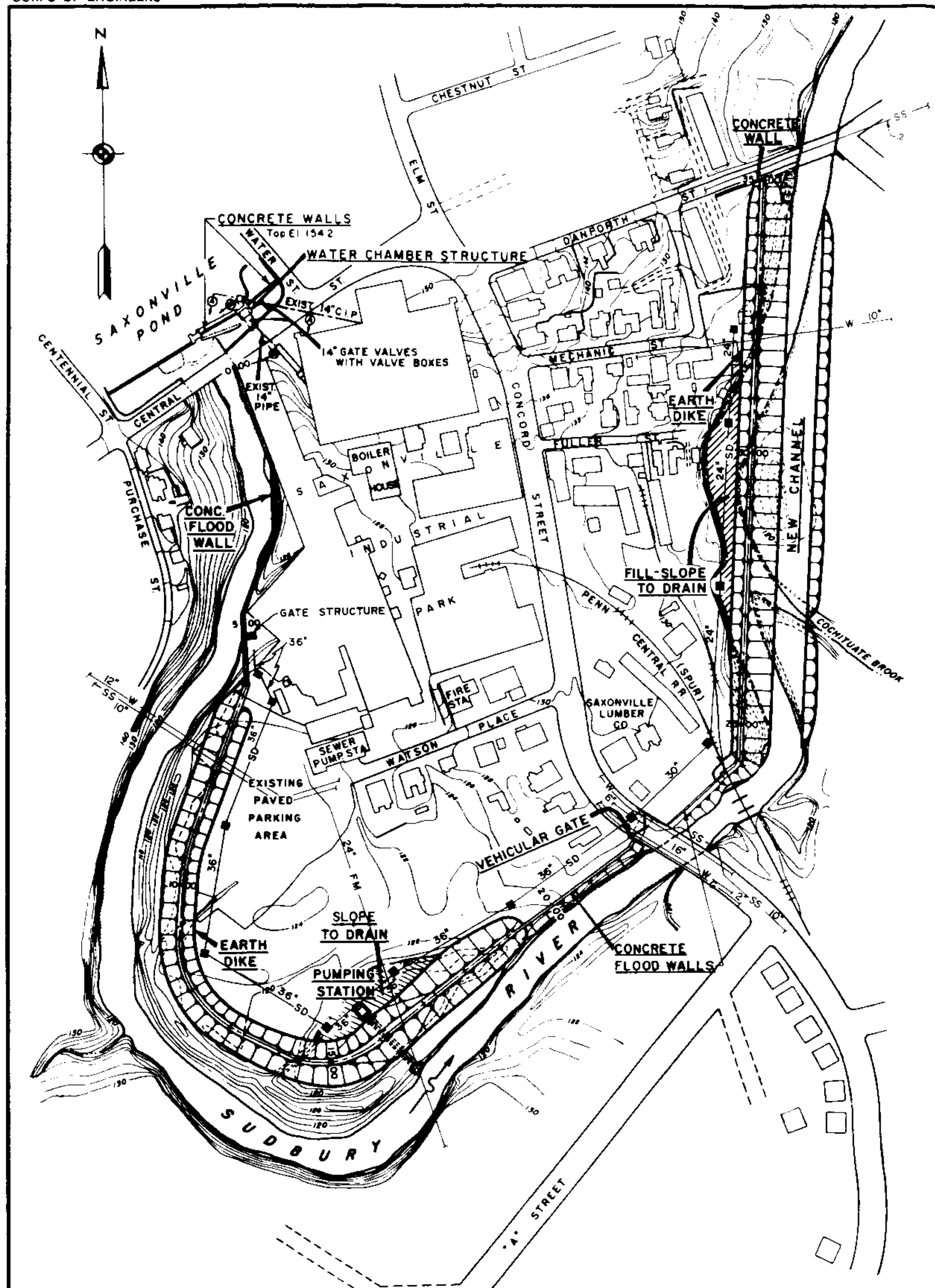
a. General - The Saxonville Pond Dam is located about 35 feet upstream of the Central Street Bridge. The existing dam is currently owned by the Saxonville Industrial Park. The existing dam will still be maintained by the owners but the new construction features (the gravity wall and sluice gate structure) will be maintained by the town. The dam is used to maintain an industrial and fire protection pool for the Industrial Park. The pool is maintained just above spillway crest at about elev. 145. The dam was probably built during the early 1900's.

b. Existing Dam - The existing dam is about 310 feet long including about 180 feet of spillway. The spillway consists of a granite block-faced masonry gravity section with an upstream impervious fill section. This spillway reaches a maximum height of 25 feet above the streambed and is constructed on bedrock. The top of the left abutment is about 4 feet higher than the adjacent spillway. Before the State of Massachusetts constructed a new bridge and abutments, this section of the dam was composed of a 25-foot wide earth fill section supported by vertical, upstream and downstream granite block retaining walls. The materials between the retaining walls consists of brown and gray brown, loose to moderately compact, gravelly silty sand (SM).

Many wood fragments were encountered in FD-18 just above the bedrock surface. The bedrock surface varies from 15 to 22 feet below the top of existing dam. Gravel contents of the sands range from 10 to 35 percent while silt contents range from 10 to 30 percent.

Recently the State of Massachusetts constructed a new bridge and abutments, widened the approach ramps, constructed a new chamber and 54 inch RCP which is aligned parallel to and adjacent to the downstream granite wall. The entire area between the new bridge abutment and the downstream granite wall was then filled with earth material and leveled to the top of existing dam.

c. New Work - The left abutment will be raised 6 feet to elev. 155.2 by constructing a new concrete gravity wall and new Sluice Gate Structure. This gate structure will rest upon bedrock which is at a depth of 15 to 20 feet while the wall will rest on an earth foundation. The estimated loadings for the wall structure are well within the allowable range for these materials. A landside drainage zone consisting of a gravel backfill, will be provided to control seepage through the foundation of the structure. It is anticipated that the water supply pool can be lowered enough so that the wall can be constructed in the dry without the use of dewatering devices. A cofferdam will be required around the sluice gate structure in order to construct it in the dry.



GENERAL PLAN

SCALE IN FEET

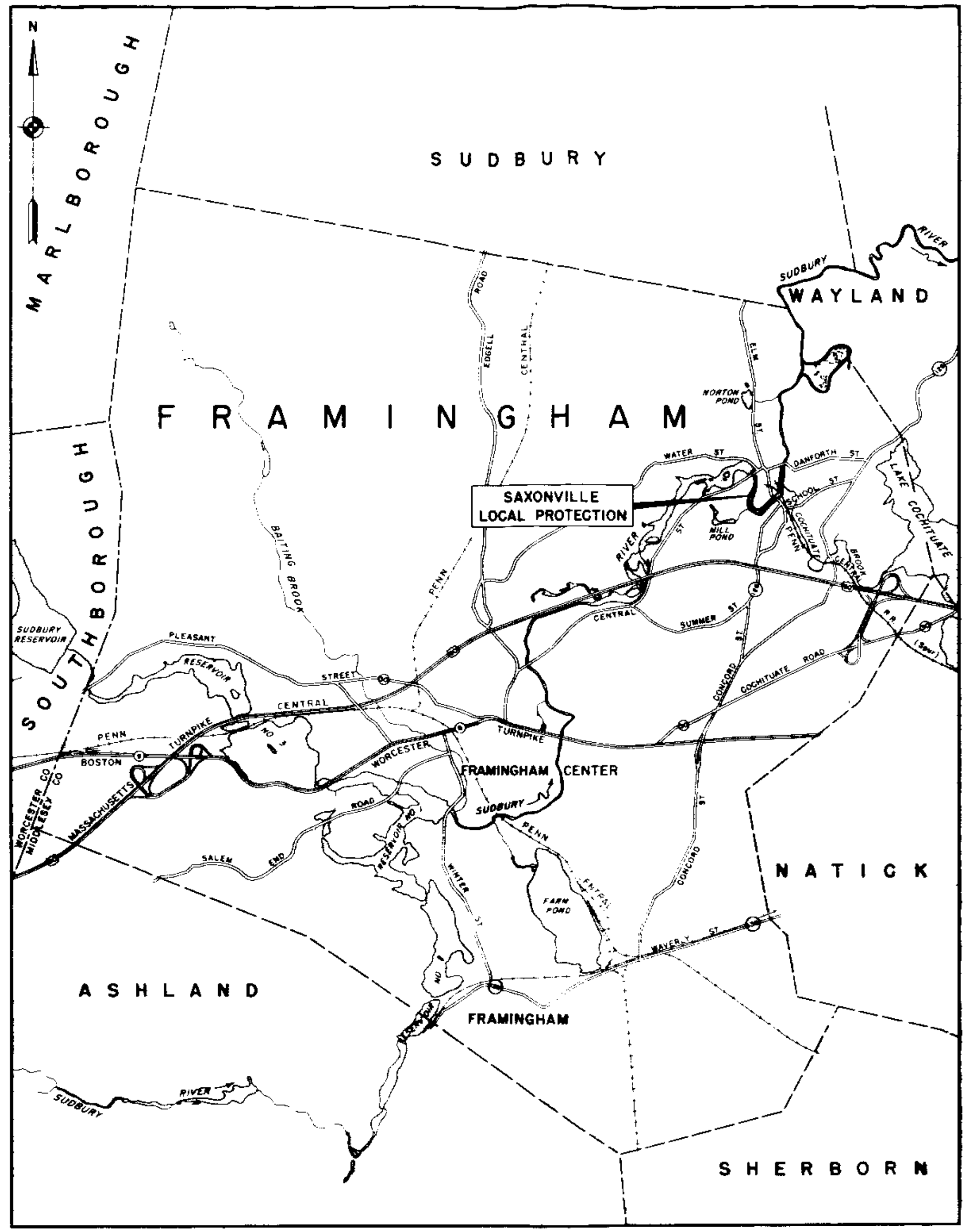
1" = 100'-0" 100 0 100 200

LEGEND — UTILITIES		
NEW	EXISTING	DESCRIPTION
—SD—		STORM DRAIN
■		DRAIN INLET
	—W—	WATER LINE
	—SS—	SANITARY LINE
	—G—	GAS LINE
	—FM—	FORCE MAIN

NOTES:

1 Topography shown is from survey by the Corps of Engineers with two-foot contour interval

2 Elevations are in feet and refer to mean sea level datum



LOCATION MAP

SCALE IN FEET

1000 0 1000 3000 5000

GRAPHIC SCALES

1" = 1'-0" 0 5 10 20

1" = 5'-0" 5 0 5 10

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DR BY J.G.M. | TR BY S.D.L. | CK BY

WATER RESOURCES DEVELOPMENT PROJECT
FRAMINGHAM, MASSACHUSETTS

SAXONVILLE LOCAL PROTECTION

GENERAL PLAN AND LOCATION MAP

SUDBURY RIVER — MASSACHUSETTS

PROJECT ENGINEER

APPROVED — DATE

CHIEF ENGINEERING DIVISION

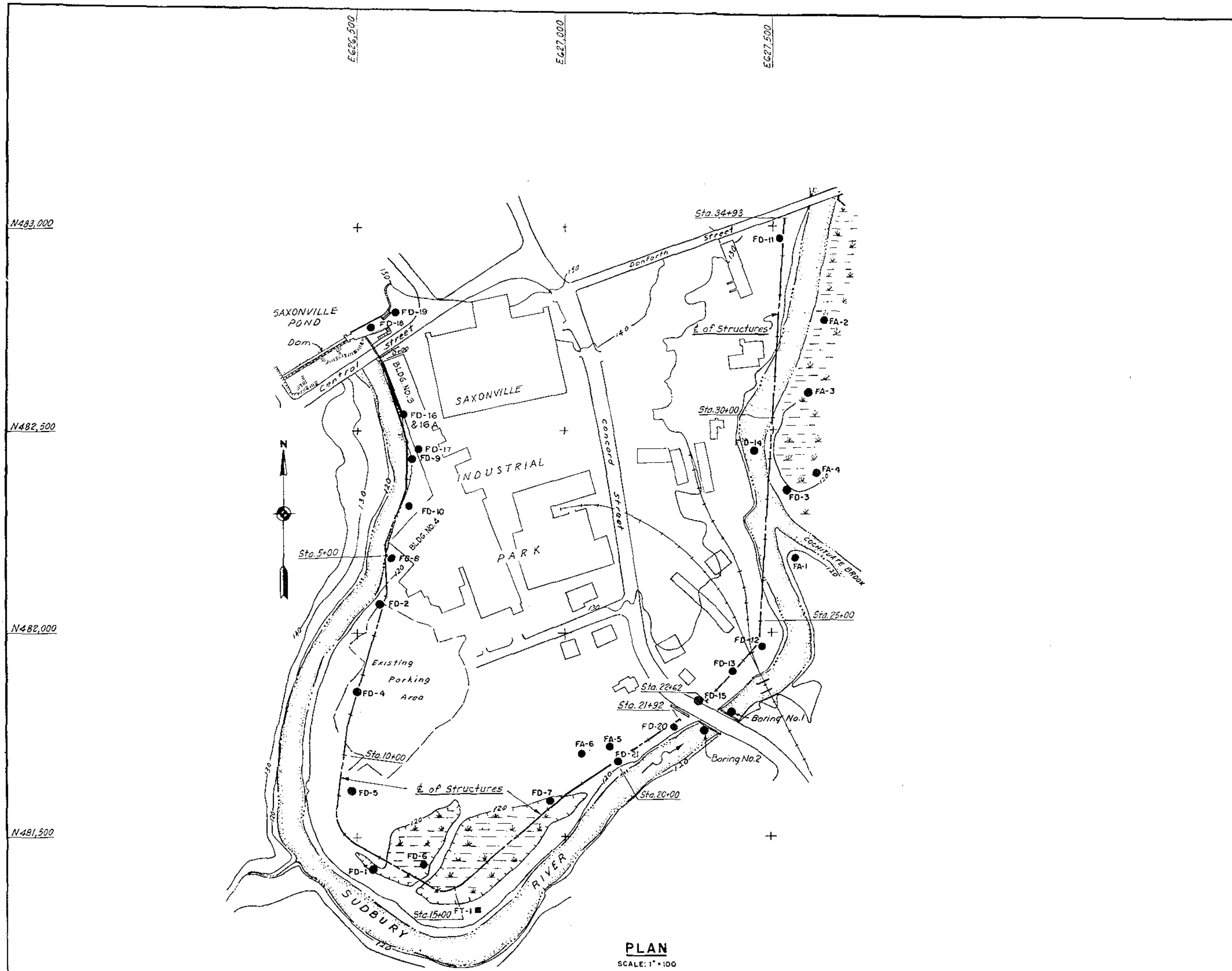
CHIEF PLANS SPECS BRANCH

SCALE AS SHOWN

DRAWING NUMBER

SHEET

PLATE 4-1



REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

BY | BY | CK. BY

SUBMITTED:

CHIEF.

APPROVAL RECOMMENDED

CHIEF.

WATER RESOURCES DEVELOPMENT PROJECT
FRAMINGHAM, MASSACHUSETTS

SAXONVILLE LOCAL PROTECTION

PLAN OF FOUNDATION EXPLORATIONS

SUDBURY RIVER — MASSACHUSETTS

APPROVED — DATE

CHIEF, ENGINEERING DIVISION

SCALE

DRAWING NUMBER

SHEET

PLATE 4-2

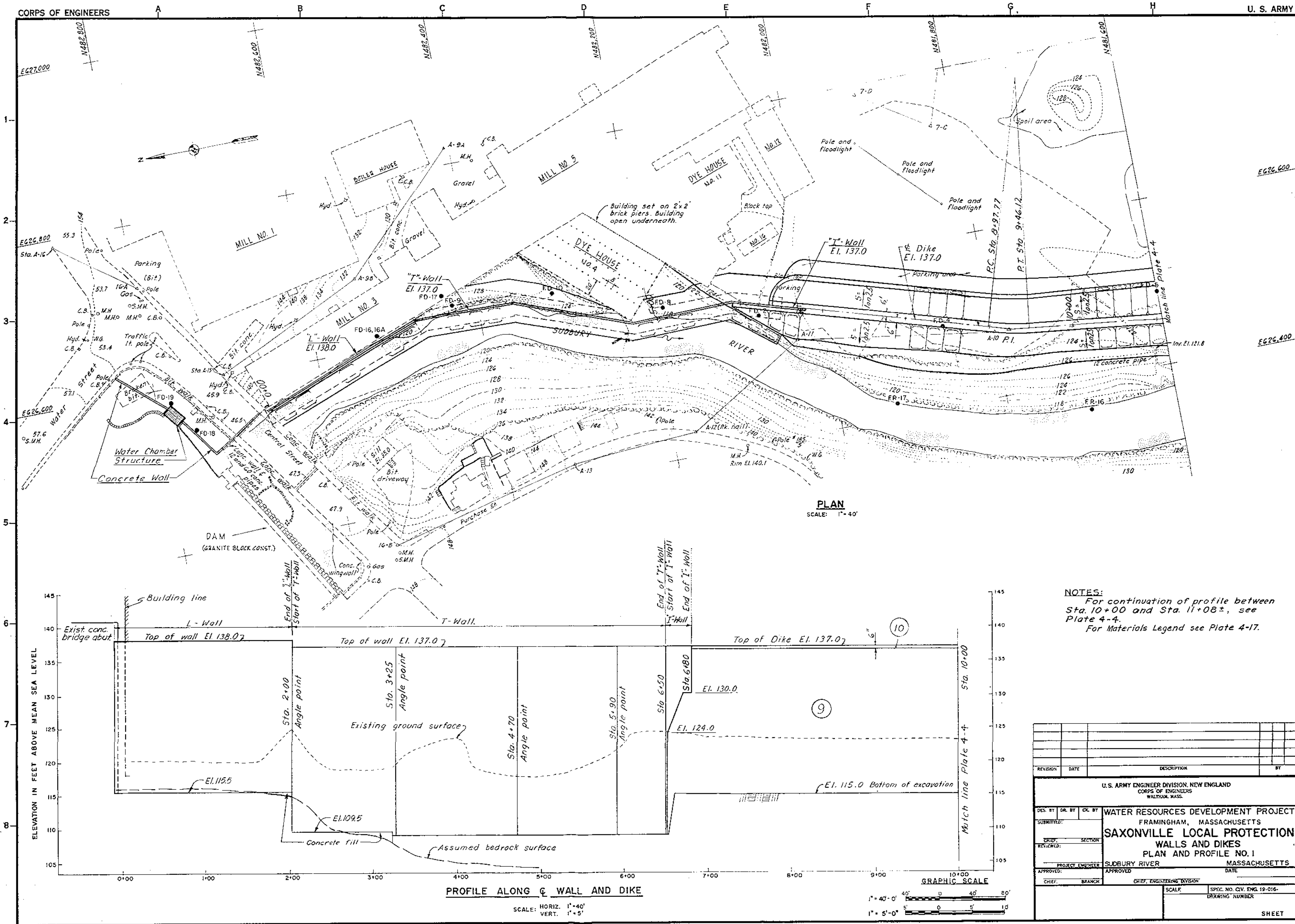

CORPS OF ENGINEERS
U. S. ARMY
MILL NO. 1
MILL NO. 3
MILL NO. 5
BOILER HOUSE
DYE HOUSE NO. 11
DYE HOUSE NO. 4
Building set on 2'x2' brick piers. Building open underneath.
"T"-Wall El. 137.0
"L"-Wall El. 138.0
℄ Dike El. 137.0
SUDBURY RIVER
Water Street
Central Street
Purchase St.
Water Chamber Structure
Concrete Wall
DAM (GRANITE BLOCK CONST.)
Spoil area
Pole and Floodlight
PLAN
SCALE: 1" = 40'
Match line Plate 4-4
NOTES:
For continuation of profile between Sta. 10+00 and Sta. 11+08±, see Plate 4-4.
For Materials Legend see Plate 4-17.
PROFILE ALONG ℄ WALL AND DIKE
SCALE: HORIZ. 1" = 40' VERT. 1" = 5'
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
Building line
Exist. conc. bridge abut.
L - Wall
T - Wall
Top of wall El. 138.0
Top of wall El. 137.0
Top of Dike El. 137.0
End of "L"-Wall Start of "T"-Wall
End of "T"-Wall Start of "I"-Wall
End of "I"-Wall
Sta. 2+00 Angle point
Sta. 3+25 Angle point
Sta. 4+70 Angle point
Sta. 5+90 Angle point
Sta. 6+50
Sta. 6+80
Sta. 10+00
El. 130.0
El. 124.0
Existing ground surface
El. 115.5
El. 109.5
Concrete fill
Assumed bedrock surface
El. 115.0 Bottom of excavation
GRAPHIC SCALE
REVISION DATE DESCRIPTION BY
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
WATER RESOURCES DEVELOPMENT PROJECT
FRAMINGHAM, MASSACHUSETTS
SAXONVILLE LOCAL PROTECTION
WALLS AND DIKES
PLAN AND PROFILE NO. 1
SUDBURY RIVER MASSACHUSETTS
SPEC. NO. CIV. ENG. 19-016-
DRAWING NUMBER
SHEET

PLATE 4-3

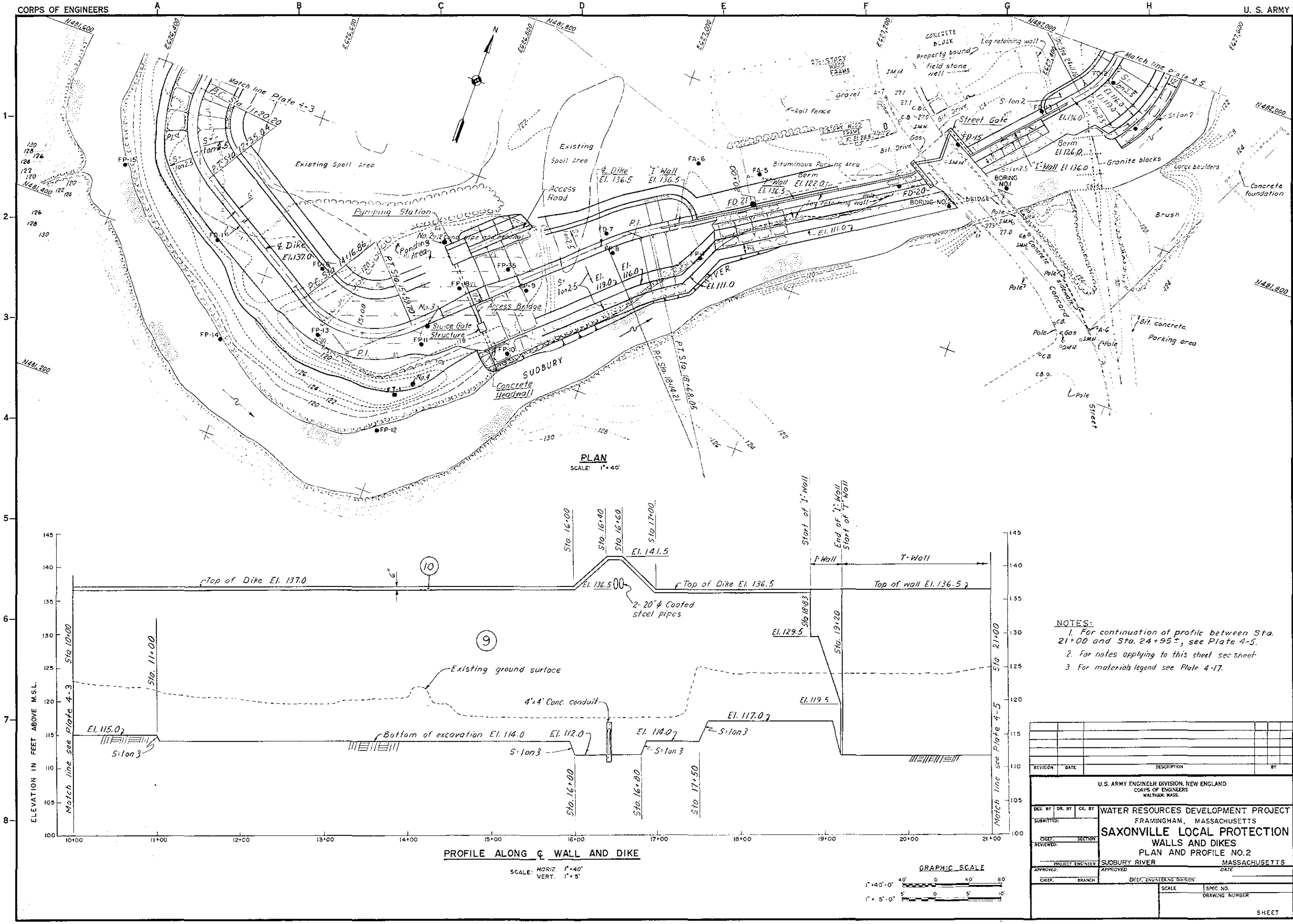

CORPS OF ENGINEERS
U. S. ARMY
PLAN
SCALE: 1" = 40'
Existing Spoil Area
Pumping Station
Sluice Gate Structure
Access Bridge
Access Road
Concrete Headwall
SUDBURY RIVER
Street Gate
Bituminous Parking Area
Concord Street
PROFILE ALONG ℄ WALL AND DIKE
SCALE: HORIZ. 1" = 40' VERT. 1" = 5'
Top of Dike El. 137.0
Top of Dike El. 136.5
Top of wall El. 136.5
2-20" ϕ Coated steel pipes
Existing ground surface
4'x4' Conc. conduit
Bottom of excavation El. 114.0
ELEVATION IN FEET ABOVE M.S.L.
NOTES:
1. For continuation of profile between Sta. 21+00 and Sta. 24+95±, see Plate 4-5.
2. For notes applying to this sheet see sheet
3. For materials legend see Plate 4-17.
GRAPHIC SCALE
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
WATER RESOURCES DEVELOPMENT PROJECT
FRAMINGHAM, MASSACHUSETTS
SAXONVILLE LOCAL PROTECTION
WALLS AND DIKES
PLAN AND PROFILE NO. 2
SUDBURY RIVER
MASSACHUSETTS

PLATE 4-4

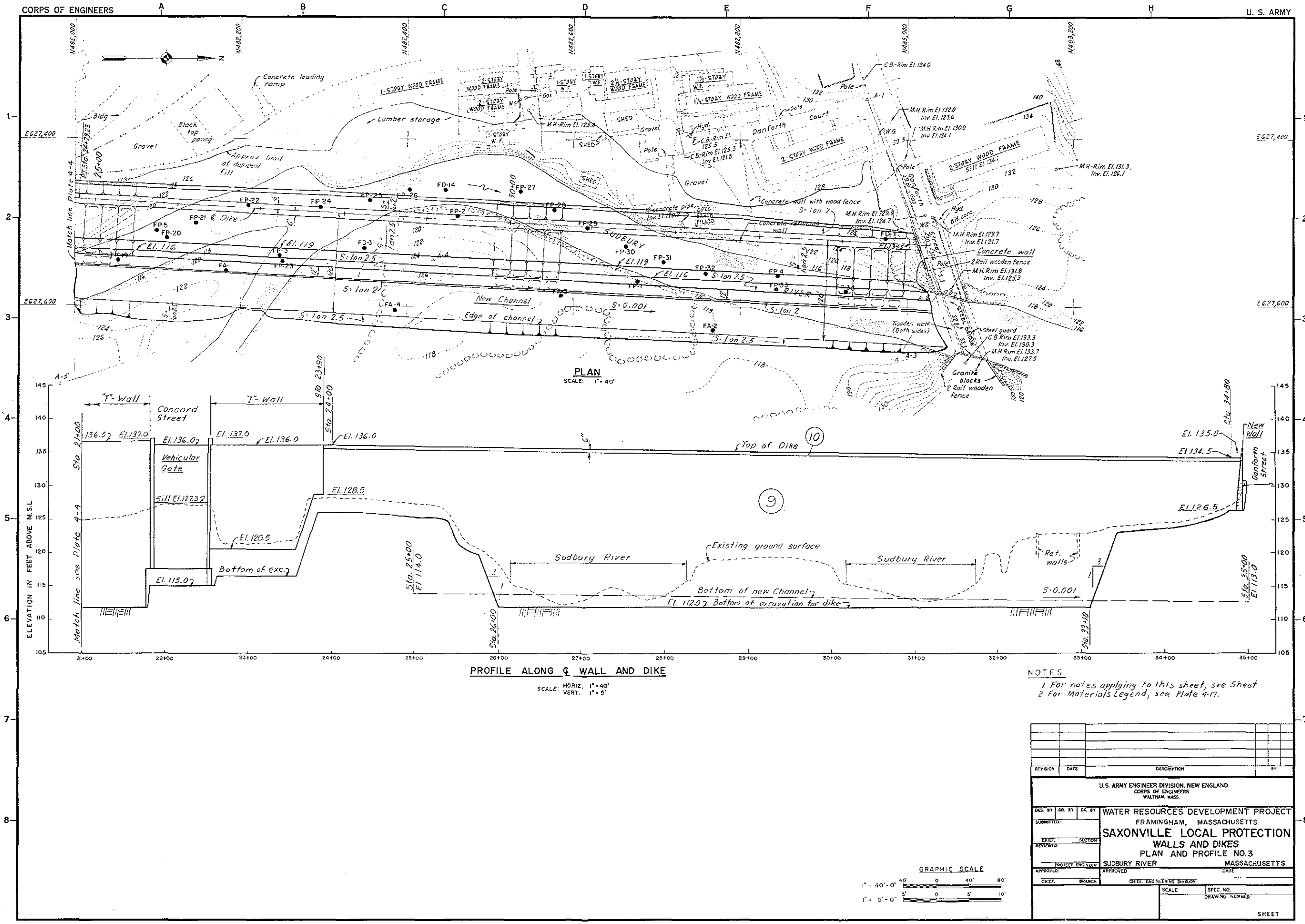
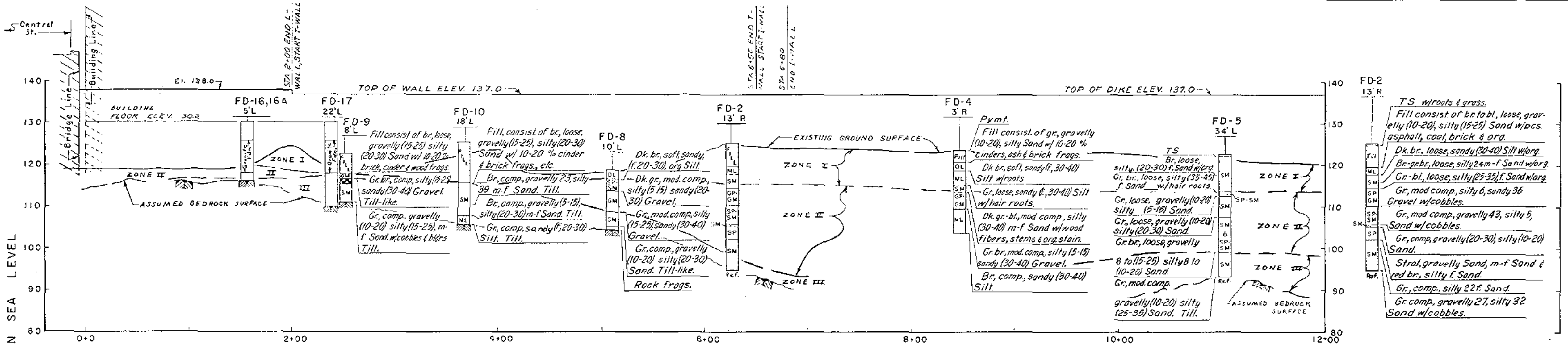

CORPS OF ENGINEERS
U. S. ARMY
PLAN
SCALE: 1" = 40'
PROFILE ALONG ℄ WALL AND DIKE
SCALE: HORIZ. 1" = 40' VERT. 1" = 5'
NOTES
1. For notes applying to this sheet, see Sheet
2. For Materials Legend, see Plate 4-17.
GRAPHIC SCALE
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
WATER RESOURCES DEVELOPMENT PROJECT
FRAMINGHAM, MASSACHUSETTS
SAXONVILLE LOCAL PROTECTION
WALLS AND DIKES
PLAN AND PROFILE NO. 3
SUDBURY RIVER MASSACHUSETTS

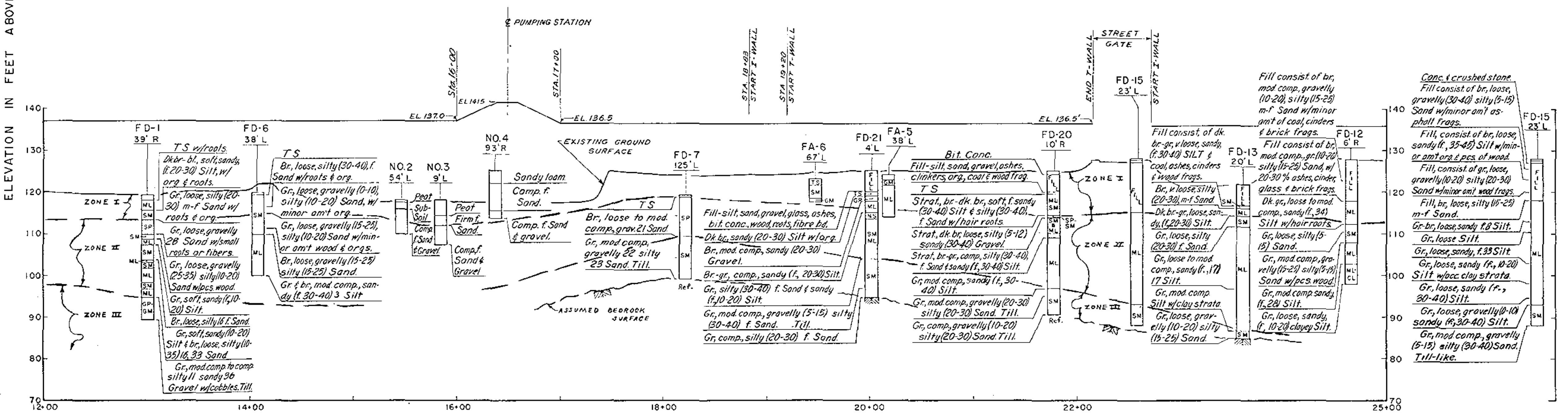
PLATE 4-5

CORPS OF ENGINEERS — U. S. ARMY

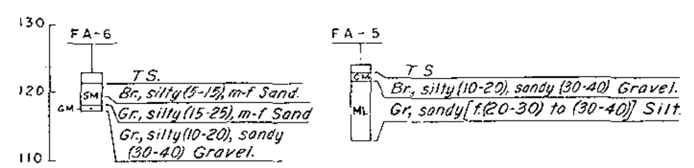


ENGINEERING LOG PROFILE A-A ALONG ℄ OF STRUCTURES

LOOKING TOWARD LANDSIDE



ENGINEERING LOG PROFILE A-A ALONG ℄ OF STRUCTURES



LEGEND FOR ENGINEERING LOGS

strat.	stratified	TS	topsoil
org.	organic	frags.	fragments
lt.	light	pcs.	pieces
dk.	dark	am't	amount
gr.	gray	conc.	concrete
br.	brown	bit.	bituminous
bl.	black	bldrs.	boulders
mod.	moderately	pvmt.	pavement
v.	very	fibrebd.	fibreboard
comp.	compact	%	percent
f.	fine	Ref.	refusal (100 blows)
m.	medium	SM	Soil Symbol, Unified Soil Classification System
c.	coarse	NP	non-plastic
m-f	medium to fine		
D_{10}	effective grain size in mm.		
occ.	occasional		
w/	with		

(25-35) A range of numbers in parentheses following a soil component in the estimated limits between which lies the percentage, by weight, of that component in the soil as determined by visual inspection.

26 A single numerical following a soil component in the description of a soil represents the percentage, by weight, of that component in the soil, as determined by a mechanical analysis.

bedrock

cobbles or boulders, continuous or nested

GRAPHIC SCALES

1" = 40' — 40' 0 40' 80'

1" = 10' — 10' 0 10' 20'

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY J B M | CK. BY

WATER RESOURCES DEVELOPMENT PROJECT
FRAMINGHAM, MASSACHUSETTS

SAXONVILLE LOCAL PROTECTION

ENGINEERING LOG PROFILE A - A

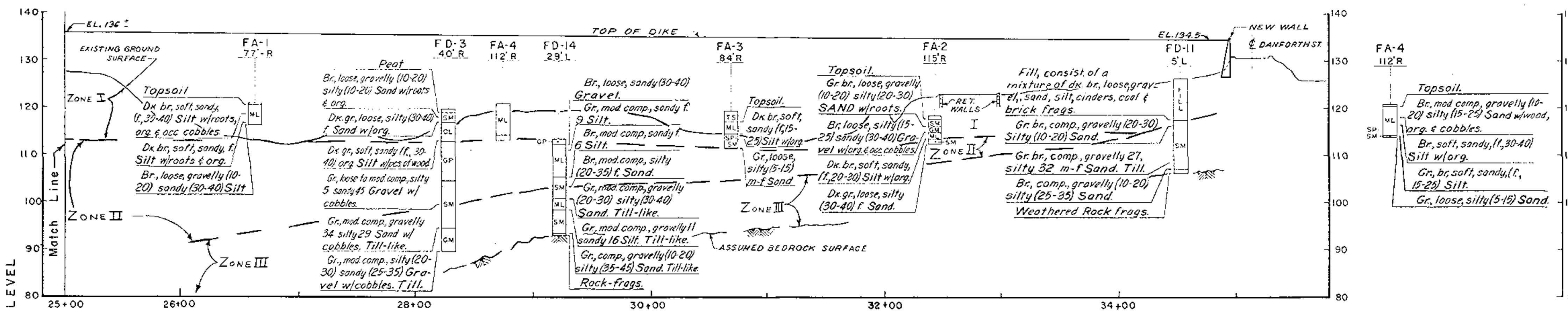
SUDBURY RIVER — MASSACHUSETTS

SUBMITTED: CHIEF, SECTION — APPROVAL RECOMMENDED: CHIEF, TECH. ENG. BRANCH — REVIEWED: PROJECT ENGINEER — APPROVAL RECOMMENDED: CHIEF, BRANCH — APPROVED — DATE — CHIEF, ENGINEERING DIVISION

SCALE — SPEC. NO. — DRAWING NUMBER — SHEET

PLATE 4-6

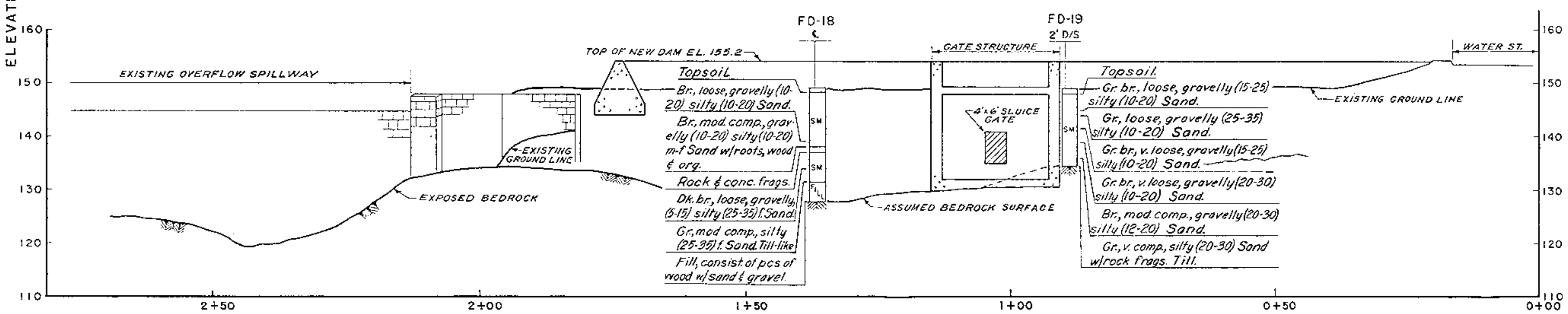
CORPS OF ENGINEERS   U. S. ARMY



ENGINEERING LOG PROFILE A-A, ALONG ℄ OF STRUCTURES

(LOOKING TOWARD LANDSIDE)

HOR. 1" = 40'
VERT. 1" = 10'



ENGINEERING LOG PROFILE B-B, ALONG CREST OF SAXONVILLE POND DAM

(LOOKING UPSTREAM)

SCALE 1" = 10'

NOTES

1. FOR LOCATION OF EXPLORATIONS SEE PLATES 4-1, 2, 3
2. SELECTED TEST DATA ARE SHOWN ON PLATES 4-9, 10, 11
3. FOR LEGEND OF ENGINEERING LOGS SEE PLATE 4-6

GRAPHIC SCALES

1" = 10' 10' 0 10' 20'

1" = 40' 40' 0 40' 80'

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY J B M | CK. BY

WATER RESOURCES DEVELOPMENT PROJECT
FRAMINGHAM, MASSACHUSETTS

SAXONVILLE LOCAL PROTECTION

ENGINEERING LOG PROFILES A-A & B-B

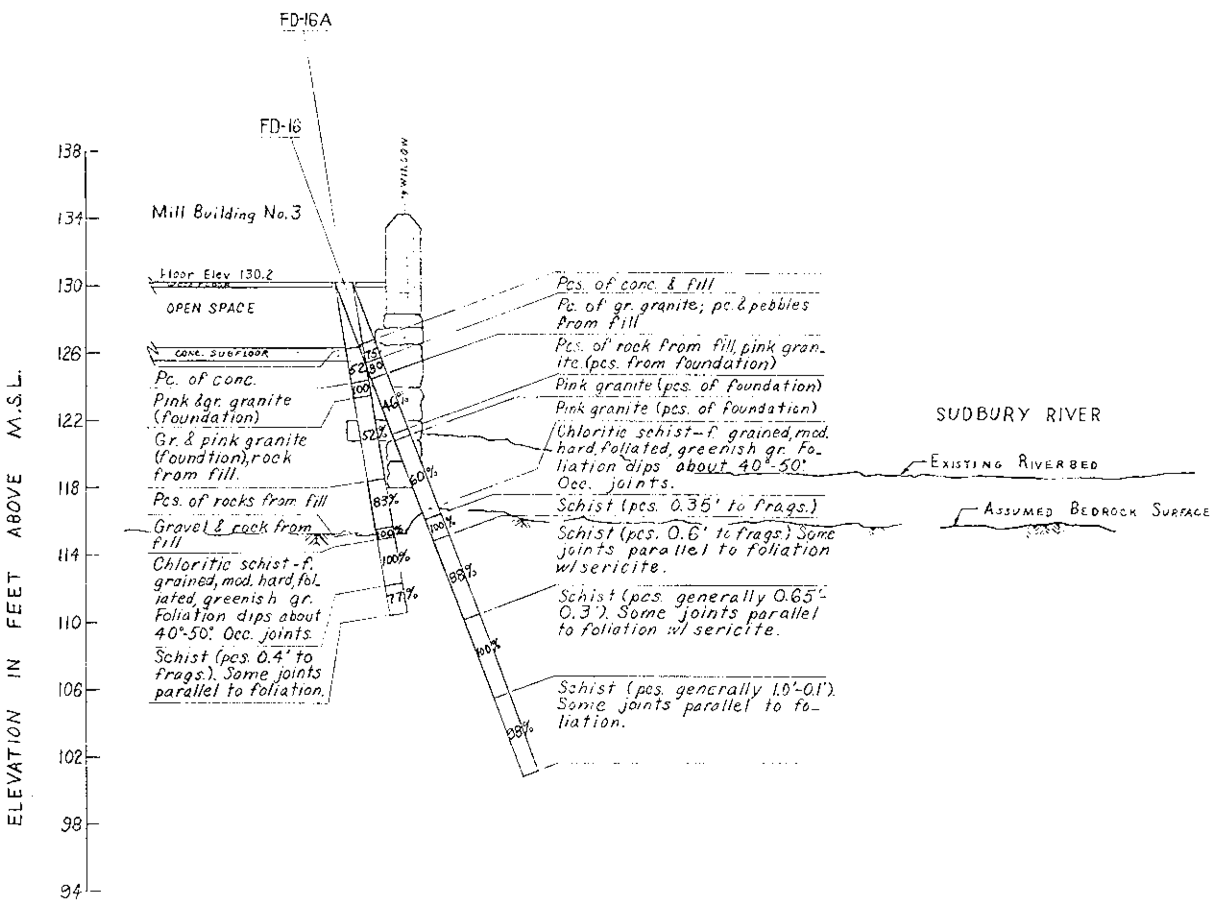
SUDBURY RIVER   MASSACHUSETTS

SUBMITTED: CHIEF, SECTION
APPROVAL RECOMMENDED: CHIEF, TECH. ENG. BRANCH
REVIEWED: PROJECT ENGINEER
APPROVAL RECOMMENDED: CHIEF, BRANCH
APPROVED: CHIEF, ENGINEERING DIVISION   DATE

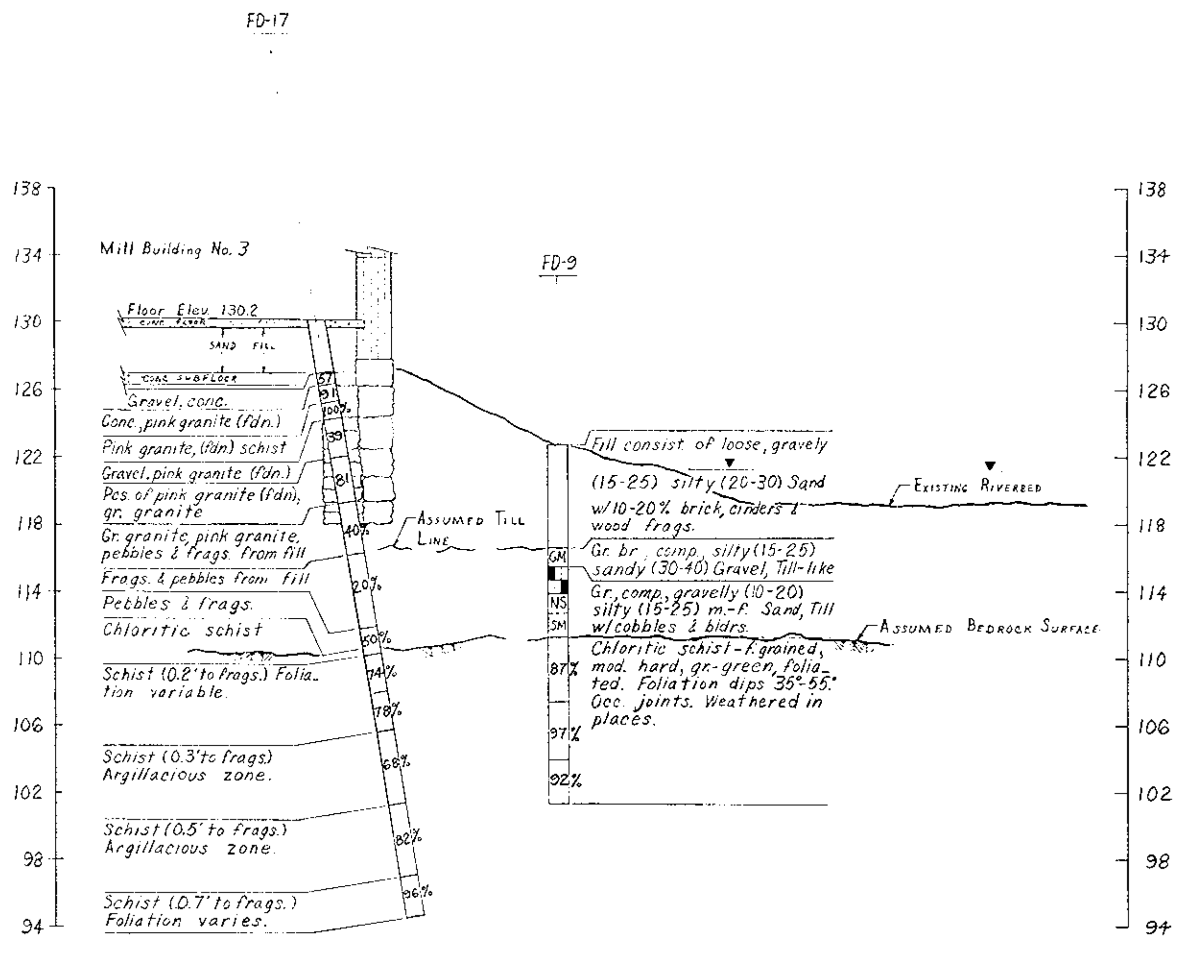
SCALE | SPEC. NO. | DRAWING NUMBER | SHEET

PLATE 4-7

CORPS OF ENGINEERS — U. S ARMY



STATION 1+55±
(LOOKING D/S)



STATION 2+50±
(LOOKING D/S)

% Rock cored recovered
fdn. Foundation

SAFETY PAYS

GRAPHIC SCALES

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

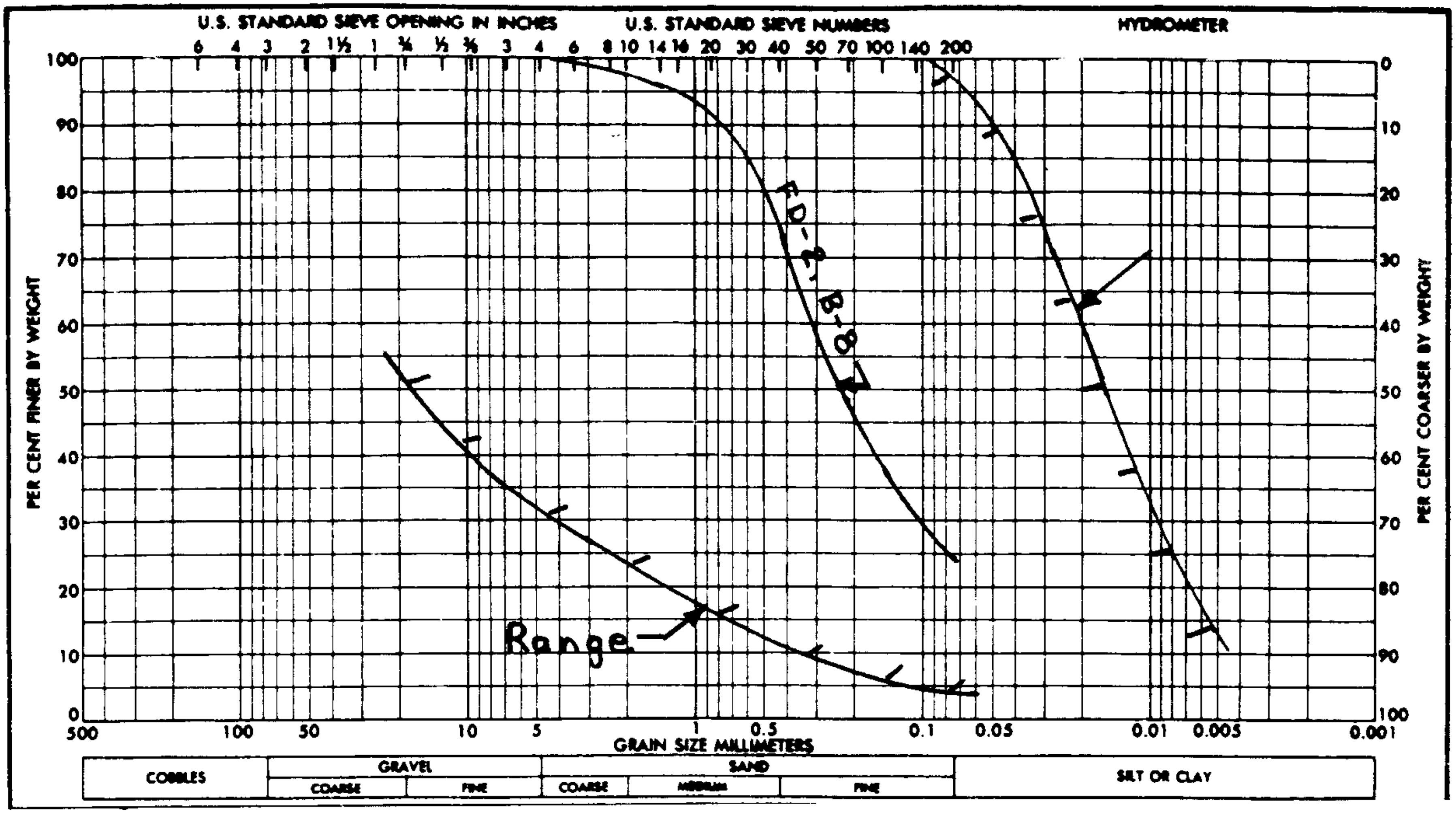
DES. BY | DR. BY | CK. BY

SUBMITTED:
CHIEF, SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF BRANCH

WATER RESOURCES DEVELOPMENT PROJECT
FRAMINGHAM, MASSACHUSETTS
SAXONVILLE LOCAL PROTECTION
FOUNDATION EXPLORATIONS AT MILL BUILDING NO. 3
SUDBURY RIVER MASSACHUSETTS

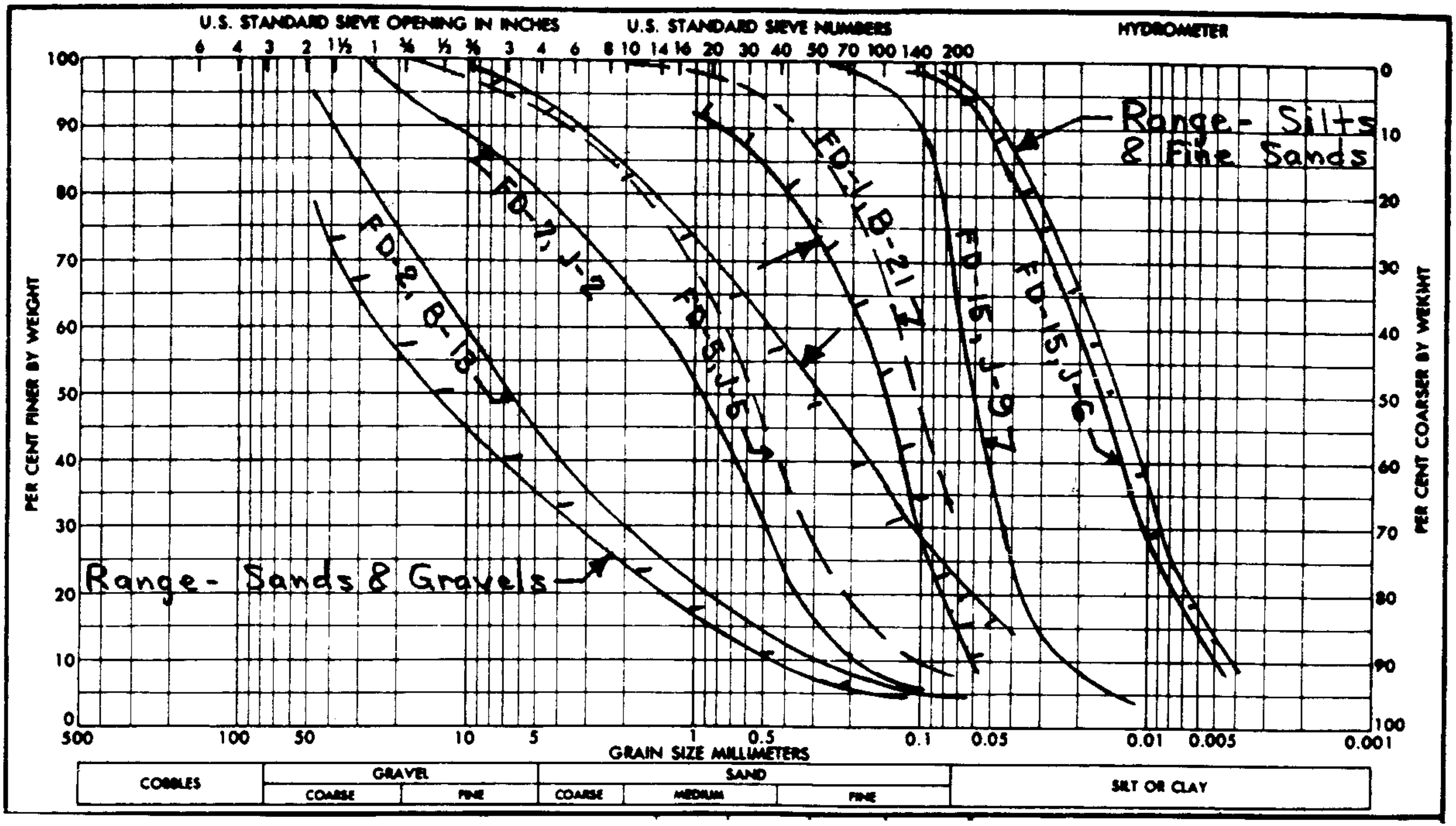
APPROVED DATE
CHIEF, ENGINEERING DIVISION

SCALE | SPEC. NO.
DRAWING NUMBER
SHEET



SAXONVILLE LOCAL PROTECTION
SELECTED TEST DATA
FOUNDATION MATERIALS - ZONE I

PLATE NO. 9



SAXONVILLE LOCAL PROTECTION
SELECTED TEST DATA
FOUNDATION MATERIALS - ZONE II

PLATE NO. 10

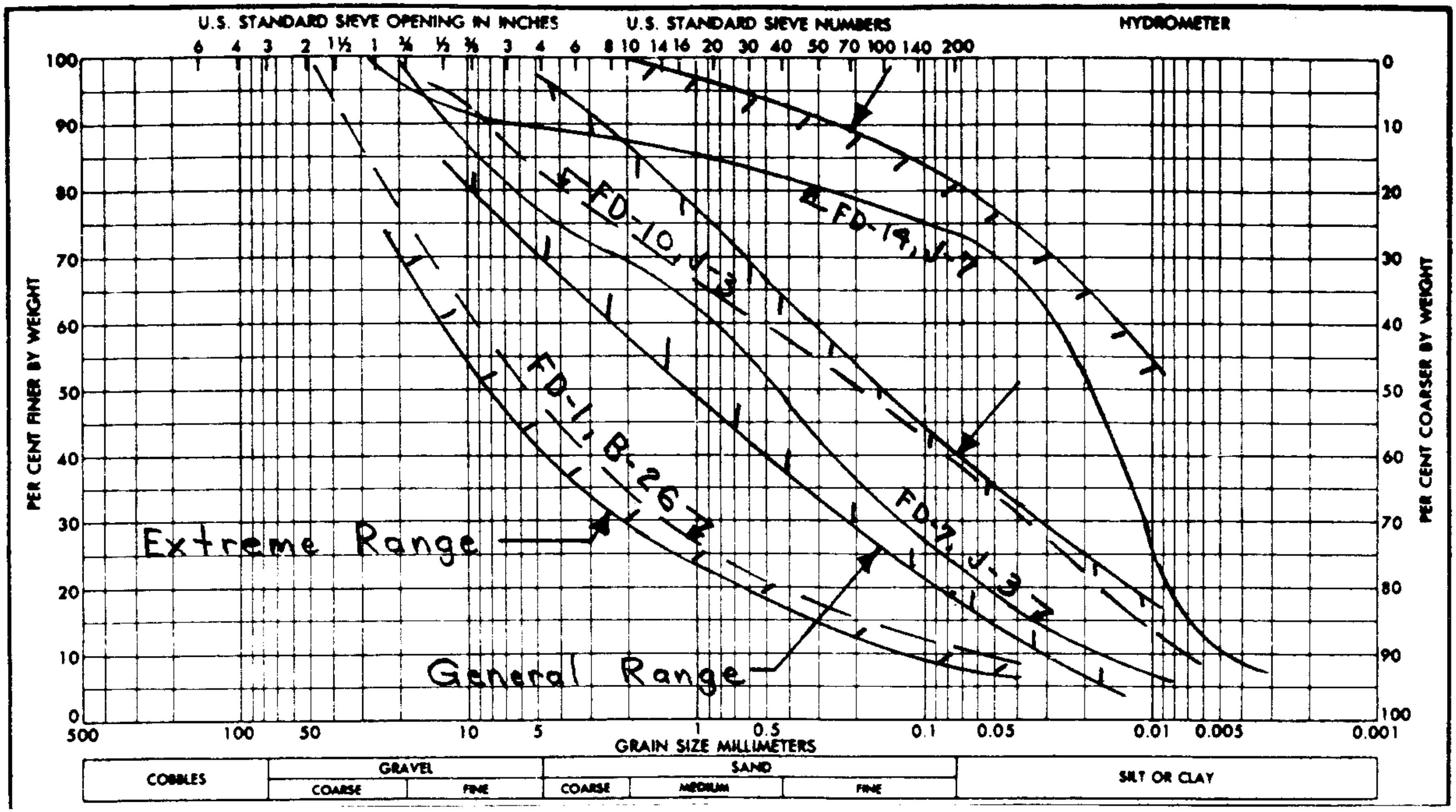
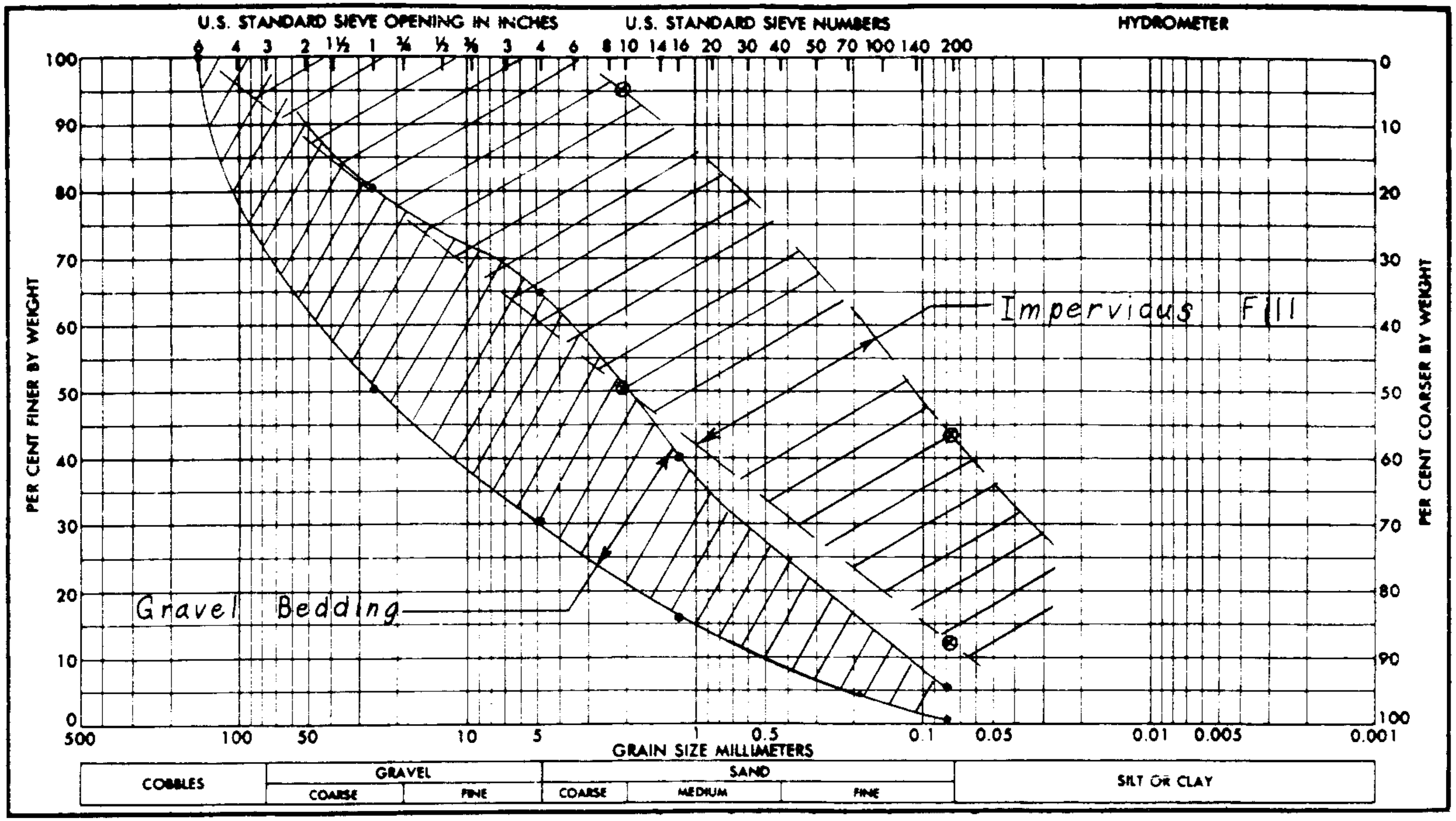


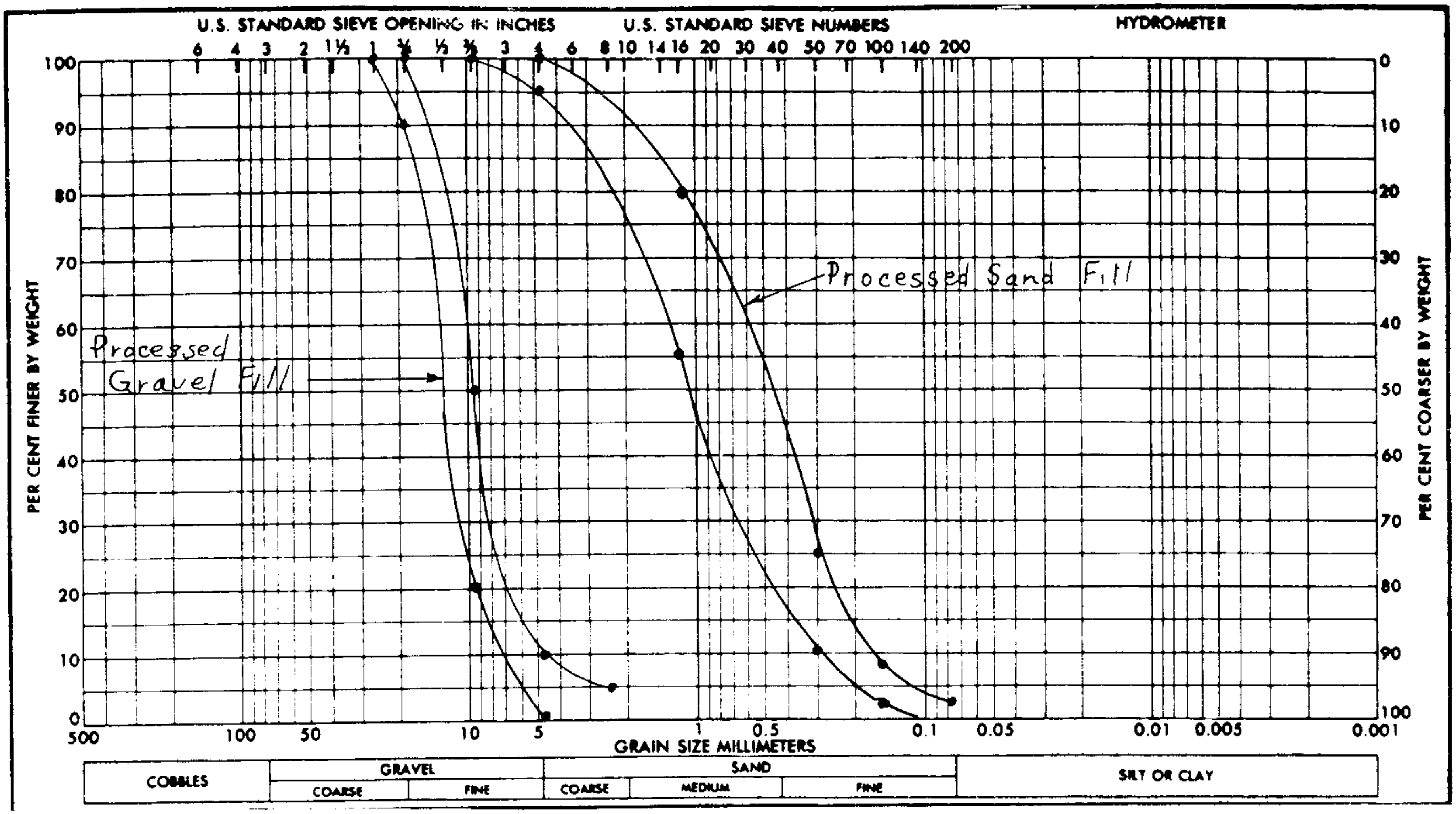
PLATE NO. 11

SAXONVILLE LOCAL PROTECTION
SELECTED TEST DATA
FOUNDATION MATERIALS - ZONE III

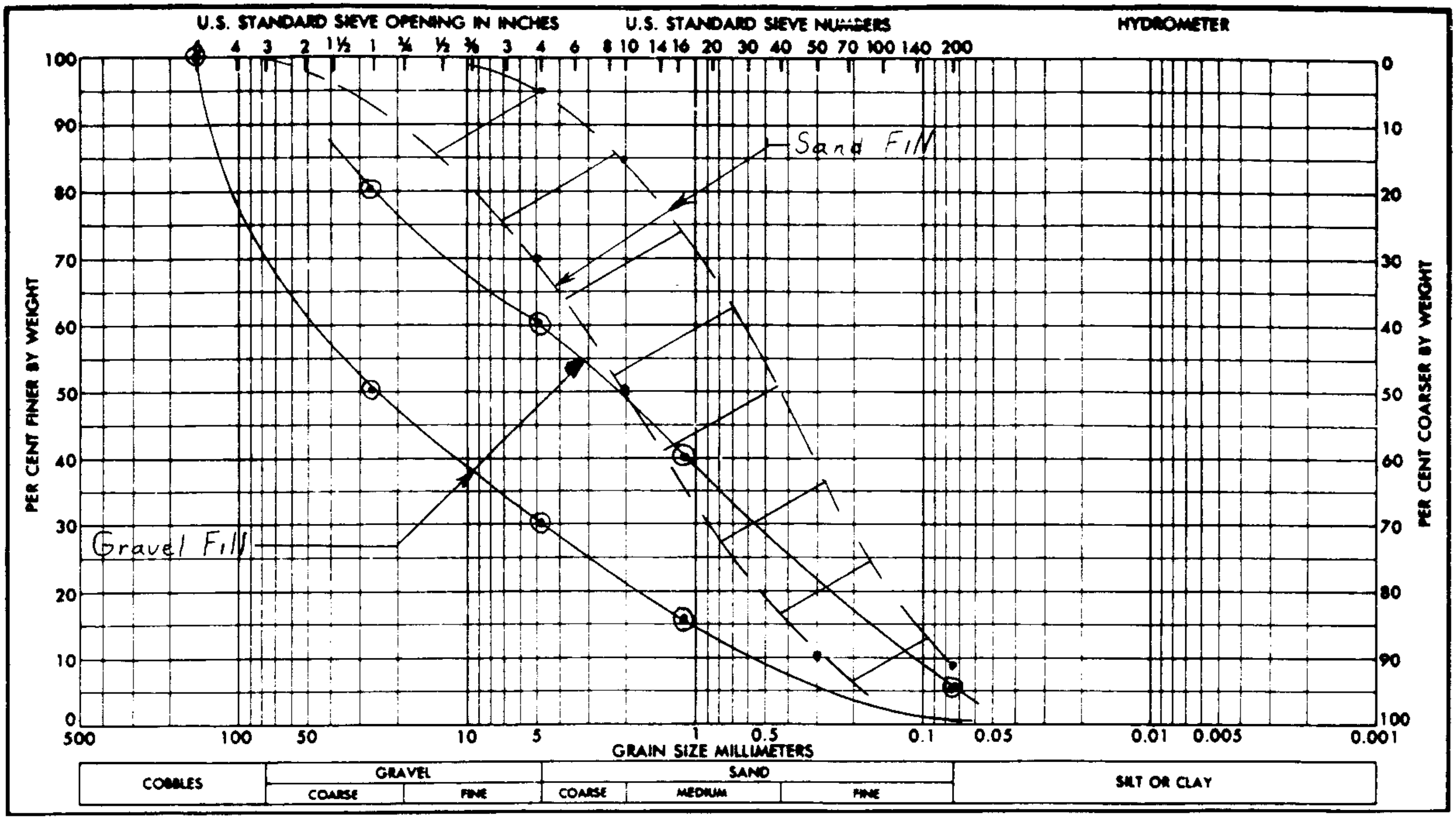


SAXONVILLE LOCAL PROTECTION
GRADATION SPECIFICATIONS
GRAVEL BEDDING AND IMPERVIOUS FILL

PLATE NO. 12

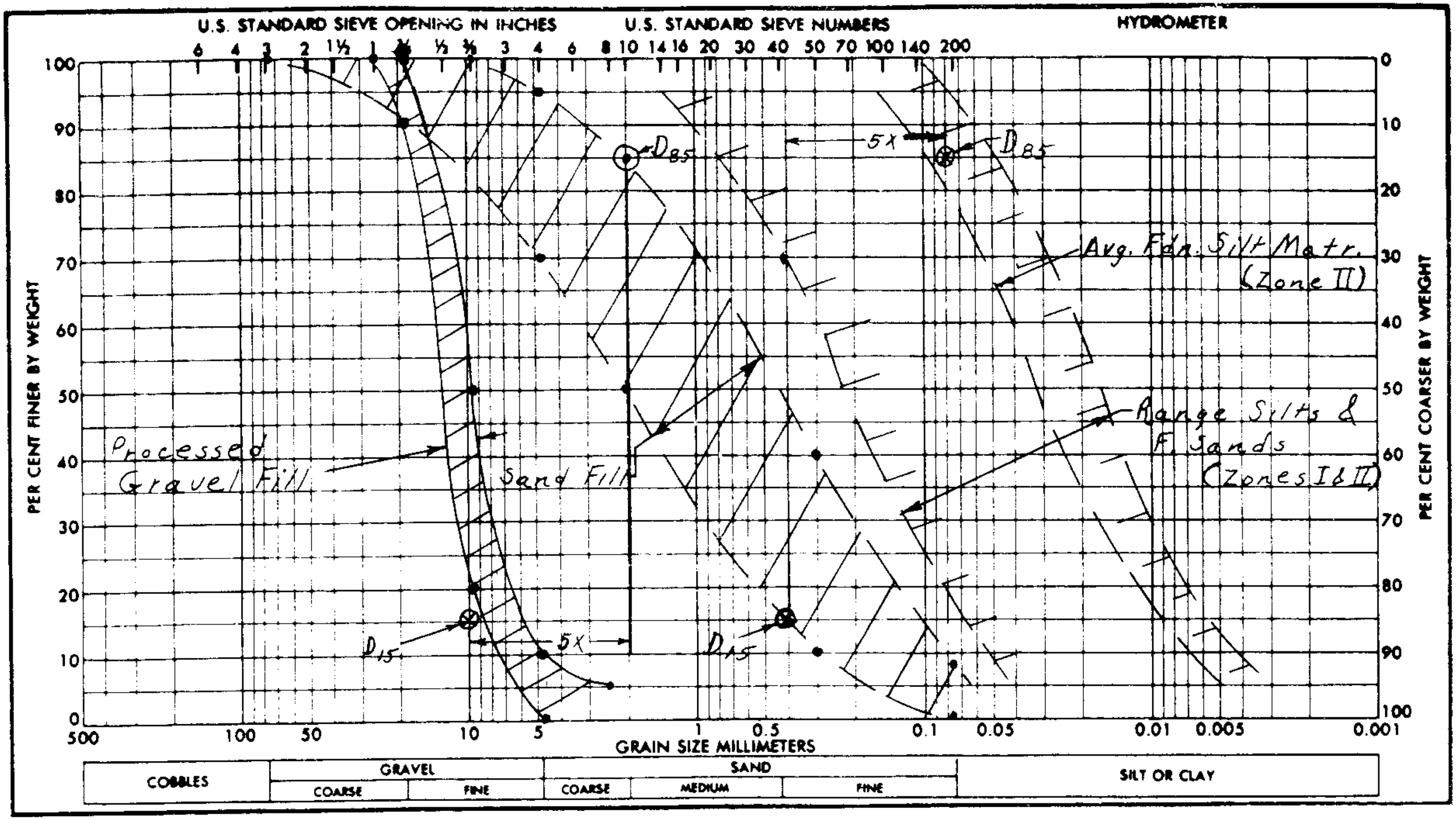


SAXONVILLE LOCAL PROTECTION
GRADATION SPECIFICATIONS
PROCESSED GRAVEL FILL AND PROCESSED SAND FILL



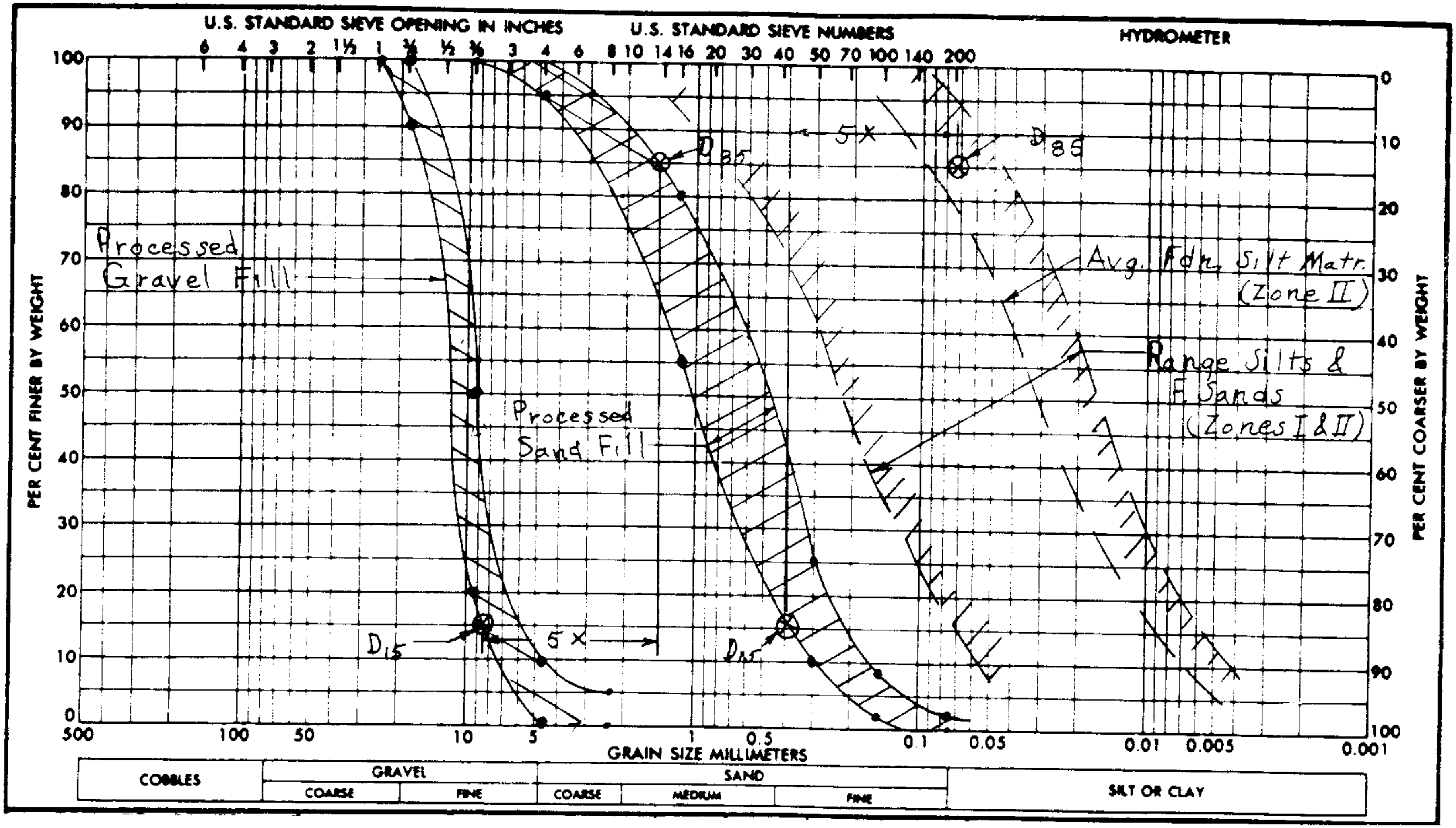
SAXONVILLE LOCAL PROTECTION
GRADATION SPECIFICATIONS
GRAVEL FILL AND SAND FILL MATERIALS

PLATE NO. 14



FILTER DESIGN - SAXONVILLE LOCAL PROTECTION NO. 1

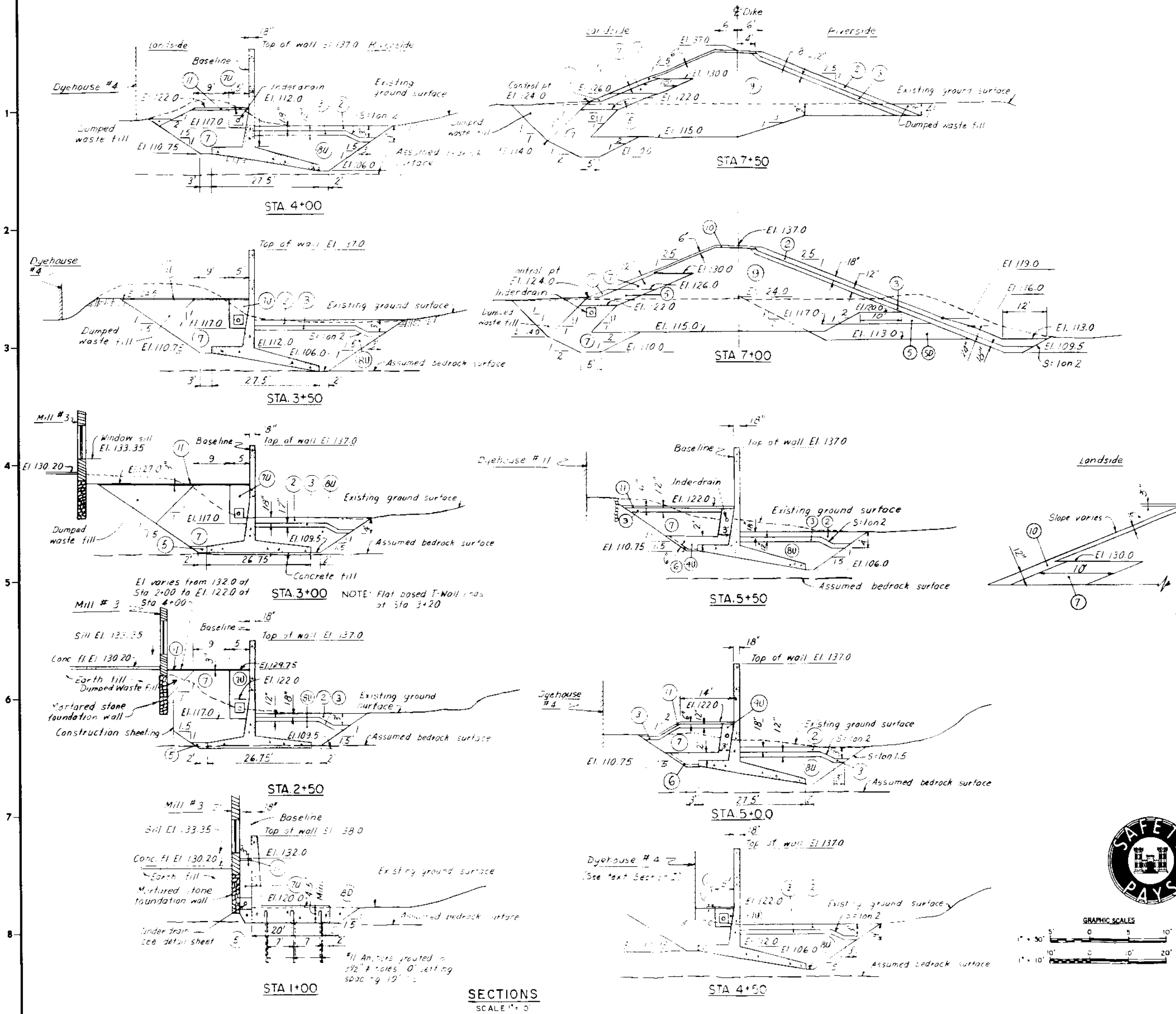
PLATE NO. 15

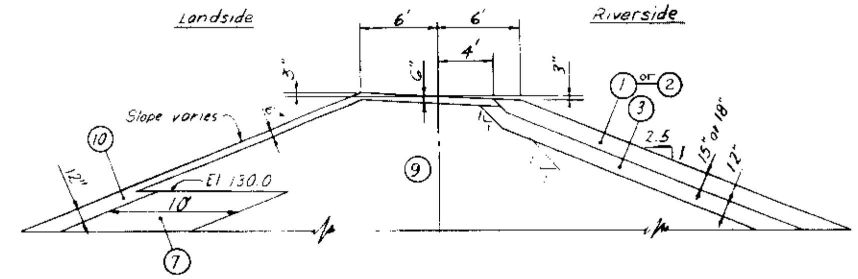


FILTER DESIGN - SAXONVILLE LOCAL PROTECTION NO. 2

PLATE NO. 16

CORPS OF ENGINEERS U. S. ARMY





TOP OF DIKE SECTION

SCALE 1"=5'

MATERIAL LEGEND

DESIGNATION	TYPE OF MATERIAL	PAYMENT ITEM NO.
1	Class I Stone Protection	
2	Class II Stone Protection	
3	Gravel Bedding	
4U	Uncompacted Processed Gravel Fill	
5	Compacted Gravel Fill	
5D	Dumped Gravel Fill	
6	Compacted Processed Sand Fill	
7	Compacted Sand Fill	
7U	Uncompacted Sand Fill	
8	Compacted Random Fill	
8U	Uncompacted Random Fill	
8D	Dumped Random Fill	
9	Compacted Impervious Fill	
10	Topsoil	
11	Crushed Stone	

NOTE For notes applying to this sheet, see sheet

GRAPHIC SCALES

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED: CHIEF, SECTION

APPROVAL RECOMMENDED: CHIEF, TECH. ENG. BRANCH

REVIEWED: PROJECT ENGINEER

APPROVAL RECOMMENDED: CHIEF BRANCH

WATER RESOURCES DEVELOPMENT PROJECT
FRAMINGHAM, MASSACHUSETTS

SAXONVILLE LOCAL PROTECTION
DIKE
TYPICAL EMBANKMENT SECTIONS NO. 1

SUDBURY RIVER MASSACHUSETTS

APPROVED DATE

CHIEF, ENGINEERING DIVISION

SCALE | SPEC. NO.

DRAWING NUMBER

SHEET

PLATE 4-17

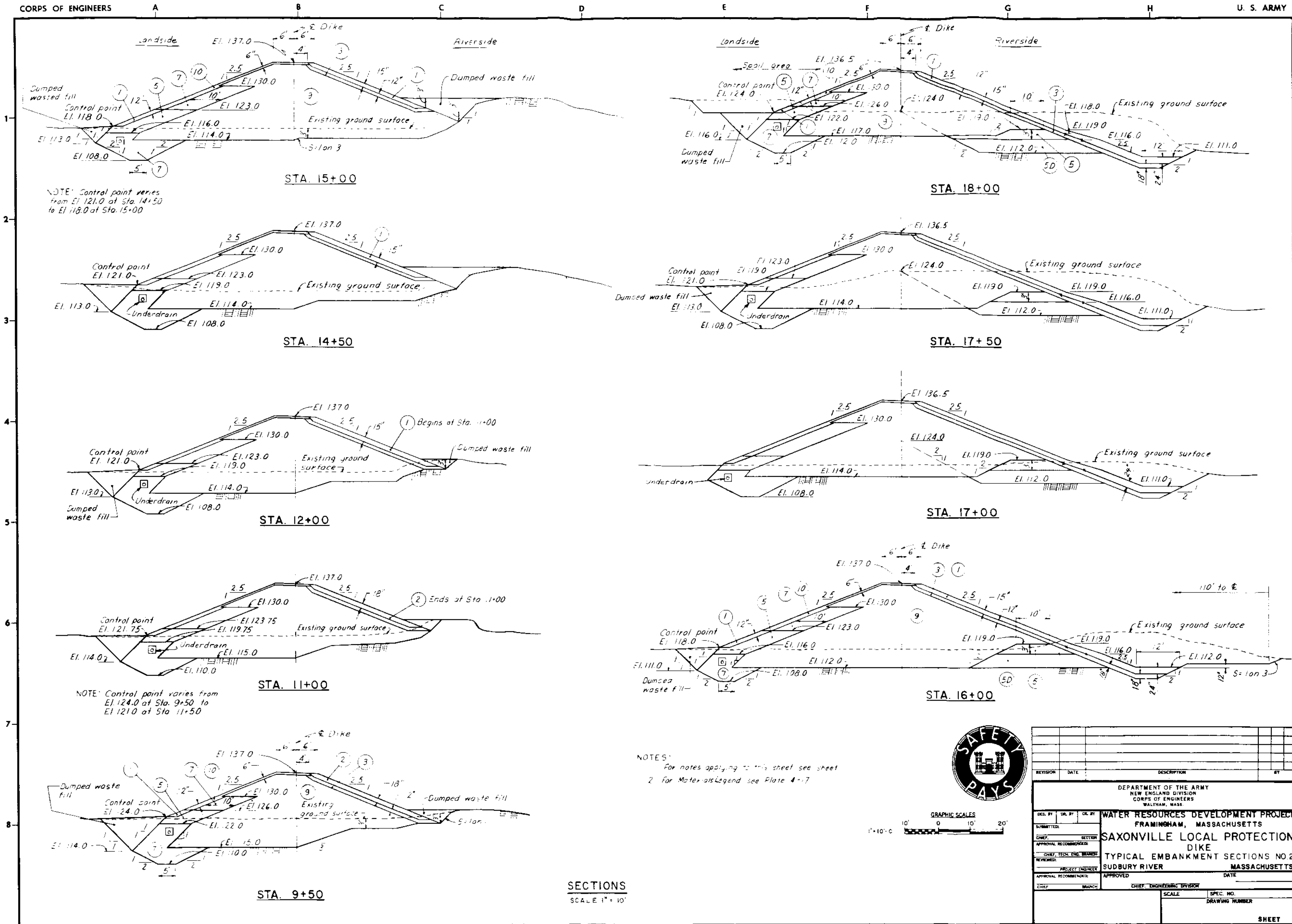

CORPS OF ENGINEERS
U. S. ARMY
Landside
Riverside
℄ Dike
STA. 15+00
NOTE: Control point varies from El 121.0 at Sta. 14+50 to El 118.0 at Sta. 15+00
STA. 14+50
STA. 12+00
STA. 11+00
NOTE: Control point varies from El. 124.0 at Sta. 9+50 to El 121.0 at Sta 11+50
STA. 9+50
STA. 18+00
STA. 17+50
STA. 17+00
STA. 16+00
Control point
Existing ground surface
Dumped waste fill
Underdrain
Spoil area
Begins at Sta. 11+00
Ends at Sta 11+00
110' to ℄
El. 137.0
El. 136.5
El. 130.0
El. 123.0
El. 124.0
El. 119.0
El. 116.0
El. 114.0
El. 112.0
El. 111.0
El. 108.0
SECTIONS
SCALE 1" = 10'
NOTES:
1. For notes applying to this sheet see sheet
2. For Materials Legend see Plate 4-17
GRAPHIC SCALES
SAFETY PAYS
REVISION
DATE
DESCRIPTION
BY
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
WATER RESOURCES DEVELOPMENT PROJECT
FRAMINGHAM, MASSACHUSETTS
SAXONVILLE LOCAL PROTECTION
DIKE
TYPICAL EMBANKMENT SECTIONS NO. 2
SUDBURY RIVER
MASSACHUSETTS
APPROVED
DATE
CHIEF, ENGINEERING DIVISION
SCALE
SPEC. NO.
DRAWING NUMBER
SHEET

PLATE 4-18

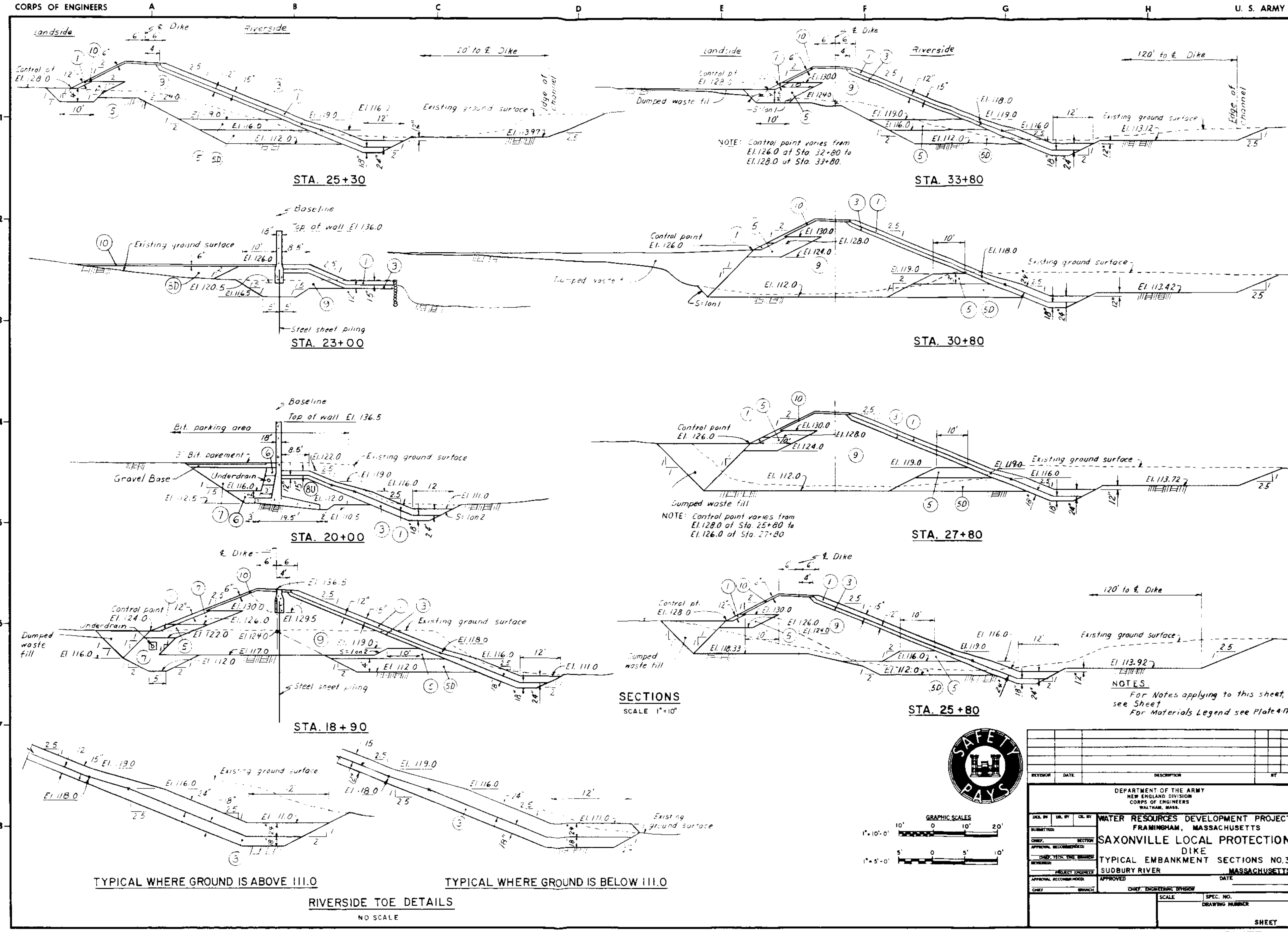
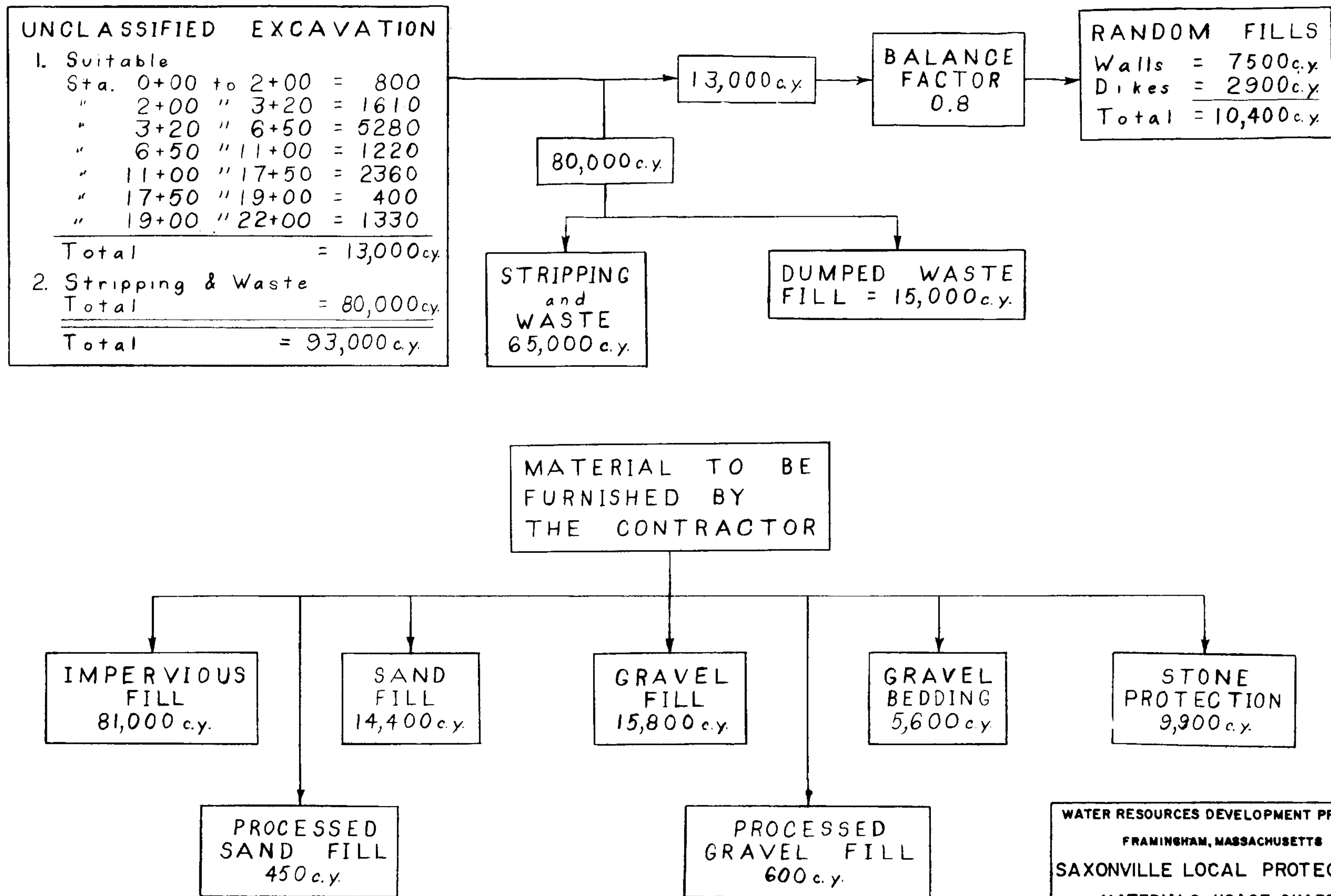

CORPS OF ENGINEERS
U. S. ARMY
STA. 25+30
STA. 33+80
NOTE: Control point varies from El. 126.0 at Sta. 32+80 to El. 128.0 at Sta. 33+80.
STA. 23+00
STA. 30+80
STA. 20+00
STA. 27+80
NOTE: Control point varies from El. 128.0 at Sta. 25+80 to El. 126.0 at Sta. 27+80
STA. 18+90
STA. 25+80
SECTIONS
SCALE 1"=10'
NOTES
For Notes applying to this sheet, see Sheet
For Materials Legend see Plate 4-17
Existing ground surface
Dumped waste fill
Steel sheet piling
Baseline
Top of wall El. 136.0
Top of wall El. 136.5
Bit. parking area
Gravel Base
Underdrain
Control point
Edge of channel
TYPICAL WHERE GROUND IS ABOVE 111.0
TYPICAL WHERE GROUND IS BELOW 111.0
RIVERSIDE TOE DETAILS
NO SCALE
SAFETY PAYS
GRAPHIC SCALES
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
WATER RESOURCES DEVELOPMENT PROJECT
FRAMINGHAM, MASSACHUSETTS
SAXONVILLE LOCAL PROTECTION
DIKE
TYPICAL EMBANKMENT SECTIONS NO. 3
SUDBURY RIVER
MASSACHUSETTS

PLATE 4-19



WATER RESOURCES DEVELOPMENT PROJECT

FRAMINGHAM, MASSACHUSETTS

SAXONVILLE LOCAL PROTECTION

MATERIALS USAGE CHART

(PRELIMINARY)

SUDBURY RIVER MASSACHUSETTS

APPENDIX A

SUMMARY OF LABORATORY TEST RESULTS

SAXONVILLE LOCAL PROTECTION

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	-NO4	COMPACTION DATA STND. AASHO OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CU FT TOTAL	-NO4	OTHER TESTS SHEAR	CONSOL.	PERM.
FD-1	119.1	B-7	5.0 - 8.5	SP	28	68	4	0.18													
		B-13	11.0-14.4	SM	0	84	16	--													
		B-21	20.0-21.5	SM	0	67	33	--													
		B-26	25.0-30.0	GP-GM	53	36	11	--													
FD-2	125.3	B-8	7.4-8.8	SM	0	76	24	--													
		B-13	10.7-15.0	GP-GM	58	36	6	0.31													
		B-15	15.0-19.6	SP-SM	43	52	5	0.15													
		B-20	23.0-25.0	SM	0	78	22	--													
		B-24	27.0-30.0	SM	27	41	32	--													
FD-3	119.5	B-11	10.0 -15.0	GP	50	45	4	0.23													
		B-14	20.0-25.0	SM	34	37	29	--													
FD-5	122.6	J-5	15.0-20.0	SP-SM	8	84	8	0.11													
FD-6	119.7	J-7	15.0-20.0	ML	0	3	97	0.0069													
FD-7	119.1	J-2	5.0-10.0	SP	21	75	4	0.19													
		J-3	10.0-15.0	SM	22	55	23	0.018													
FD-10	125.4	J-3	10.0-15.0	SM	23	38	39	0.007													
FD-11	126.1	J-4	10.0-15.0	SM	27	41	32	0.013													
FD-12	127.9	J-3	10.0-15.0	ML	0	34	66	0.0055													
		J-7	20.0-25.0	ML	0	28	72	0.019													

NED FORM JUL 63 510 * PROVIDENCE VIBRATED DENSITY TEST

SAXONVILLE LOCAL PROTECTION

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS				ATT. LIMITS		SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT		COMPACTION DATA			NAT. DRY DENSITY LBS/CU FT		OTHER TESTS		
					GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL		TOTAL	- NO 4	STND. AASHO OPT. WATER % DRY WT	STND. AASHO MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	- NO 4	SHEAR	CONSOL.	PERM.
FD-13	121.7	J-5	10.0-15.0	ML	0	17	83	0.0072													
		J-7	20.0-25.0	ML	0	17	83	0.007													
FD-14	113.4	J-2	1.1-2.3	ML	3	9	88	0.0051													
		J-4	5.0-8.0	ML	0	6	94	0.0044													
		J-7	12.5-15.0	ML	11	16	73	0.0045													
FD-15	130 ±	J-6	10.0-14.8	ML	0	8	92	0.0048													
		J-9	17.5-20.0	ML	0	33	67	0.022	NP	NP											

NED FORM JUL 63 510   * PROVIDENCE VIBRATED DENSITY TEST

SAXONVILLE LOCAL PROTECTION

APPENDIX B

TABLE - FOUNDATION PROBES

SAXONVILLE LOCAL PROTECTION

TABLE - FOUNDATION PROBES

FP NO.	TOP ELEV.	PUSHED PENETRATION WEIGHT OF 1 MAN	PUSHED PENETRATION WEIGHT OF 2 MEN	DEPTH RANGE HAMMERED	HAMMERED PENETRATION DEPTHS & BLOWS/FT. (8# HAMMER) 1st	2nd	3rd	4th	5th	5th	7th	8th
1	118.7	0.0-1.8	1.8-2.1	2.1-9.8	3/0.9	6	9	10	12	18	20	36/0.8
2	119.6	0.0-3.5	—	3.5-9.2	54/0.5	62	50	18	17	23	24/0.2	*—
3	114.7	0.0-2.3	—	2.3-3.5	37/0.7	98/0.5	*—	—	—	—	—	—
4	114.6	0.0-1.4	1.4-3.0	3.0-5.8	18	25	37/0.8	*—	—	—	—	—
5	114.8	0.0-2.0	—	2.0-4.3	12	25	38/0.3	*—	—	—	—	—
6	115.3	0.0-1.3	—	1.3-4.5	8/0.7	17	13	39/0.5	—	—	—	—
7	117.1	0.0-2.8	2.8-3.0	3.0-6.3	23	25	37	42/0.3	—	—	—	—
8	118.2†	0.0-1.0	—	1.0-4.7	10	36	48	76/0.7	—	—	—	—
9	118.2†	0.0-3.0	—	3.0-6.4	15	22	40	32/0.4	*—	—	—	—
10	121.1	0.0-3.5	—	3.5-6.3	15/0.5	22	40	52/0.3	—	—	—	—
11	117.9	0.0-1.3	—	1.3-7.4	19/0.7	8	10	12	27	30	48/0.4	—
12	115.8	0.0-3.1	—	3.1-5.8	11/0.9	14	25/0.8	*—	—	—	—	—
13	117.9	0.0-1.3	—	1.3-7.5	8/0.7	12	17	19	26	27	30/0.5	—
14	116.5	0.0-1.4	—	1.4-6.6	5/0.6	7	8	21	20	25/0.6	—	—
15	116.1	0.0-2.7	—	2.7-8.8	8/0.3	15	15	32	30	16	22/0.8	—
16	115.8	0.0-2.0	—	2.0-8.5	12	17	18	47	42	35	56/0.5	—
17	116.7	0.0-1.1	—	1.1-2.8	11/0.9	48/0.8	*—	—	—	—	—	—
18	117.7†	0.5-1.0	1.0-4.2	4.2-5.2	64	—	—	—	—	—	—	—
19	113.7	0.0-0.1	0.1-0.2	0.2-1.2	59/0.8	39/0.2	—	—	—	—	—	—
20	113.9	0.0-0.3	0.3-0.4	0.4-1.4	28/0.6	39/0.4	—	—	—	—	—	—
21	113.6	0.0-0.4	—	0.4-1.4	69/0.6	49/0.4	—	—	—	—	—	—
22	113.4	0.0-0.2	0.2-0.4	0.4-1.4	30/0.6	33/0.4	—	—	—	—	—	—
23	115.0	0.0-0.7	—	0.7-1.7	31/0.3	69/0.7	—	—	—	—	—	—
24	113.5	—	0.0-0.2	0.2-1.2	52	—	—	—	—	—	—	—
25	113.1	0.0-0.2	0.2-1.0	1.0-2.0	65	—	—	—	—	—	—	—
26	113.1	0.0-0.5	—	0.5-1.5	16/0.5	17/0.5	—	—	—	—	—	—
27	113.2	0.0-0.7	—	0.7-2.7	38	47	—	—	—	—	—	—
28	113.2	0.0-0.1	0.1-0.4	0.4-2.5	41/0.6	30	59/0.5	—	—	—	—	—
29	112.9	0.0-0.8	—	0.8-1.8	48	—	—	—	—	—	—	—
30	113.1	0.0-0.5	0.5-1.1	1.1-2.1	77	—	—	—	—	—	—	—
31	113.5	0.0-0.2	0.2-0.4	0.4-1.4	45	—	—	—	—	—	—	—
32	113.8	0.0-0.2	0.2-0.3	0.3-1.3	45	—	—	—	—	—	—	—
33	113.8	0.0-0.2	0.2-0.3	0.3-1.3	50	—	—	—	—	—	—	—
34	113.6	—	—	0.0-1.0	56	—	—	—	—	—	—	—
35	117.7†	0.5-2.0	2.0-4.3	4.3-5.3	60	—	—	—	—	—	—	—

*Indicates refusal.
† Elevation taken on ice.
FP-18 and FP-35 drove "E" rod through ice 0 0-0.5.
25/0.5 Indicates blows per fractional foot of penetration.